



This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

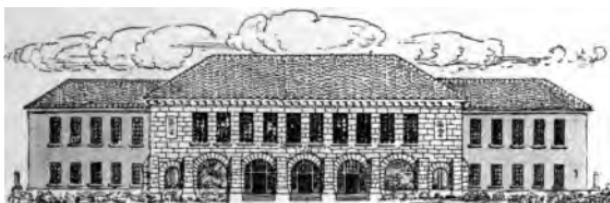
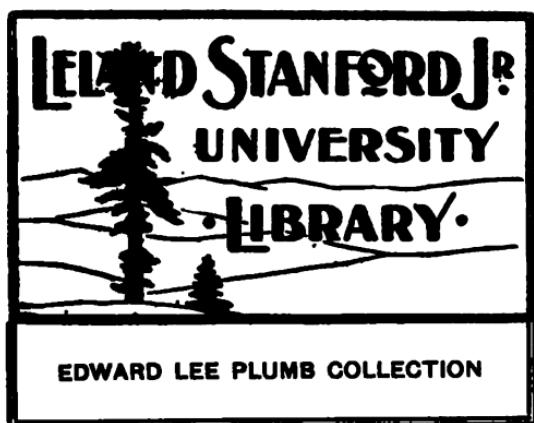
Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

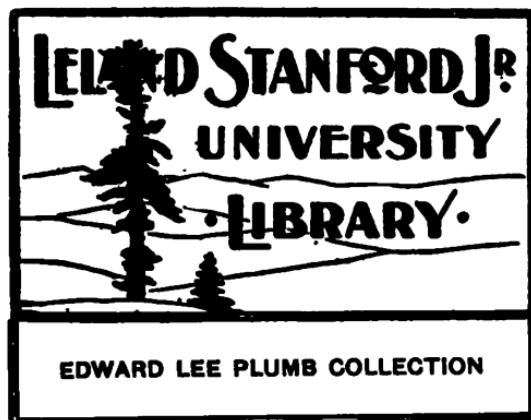
- + *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
- + *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
- + *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
- + *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at <http://books.google.com/>



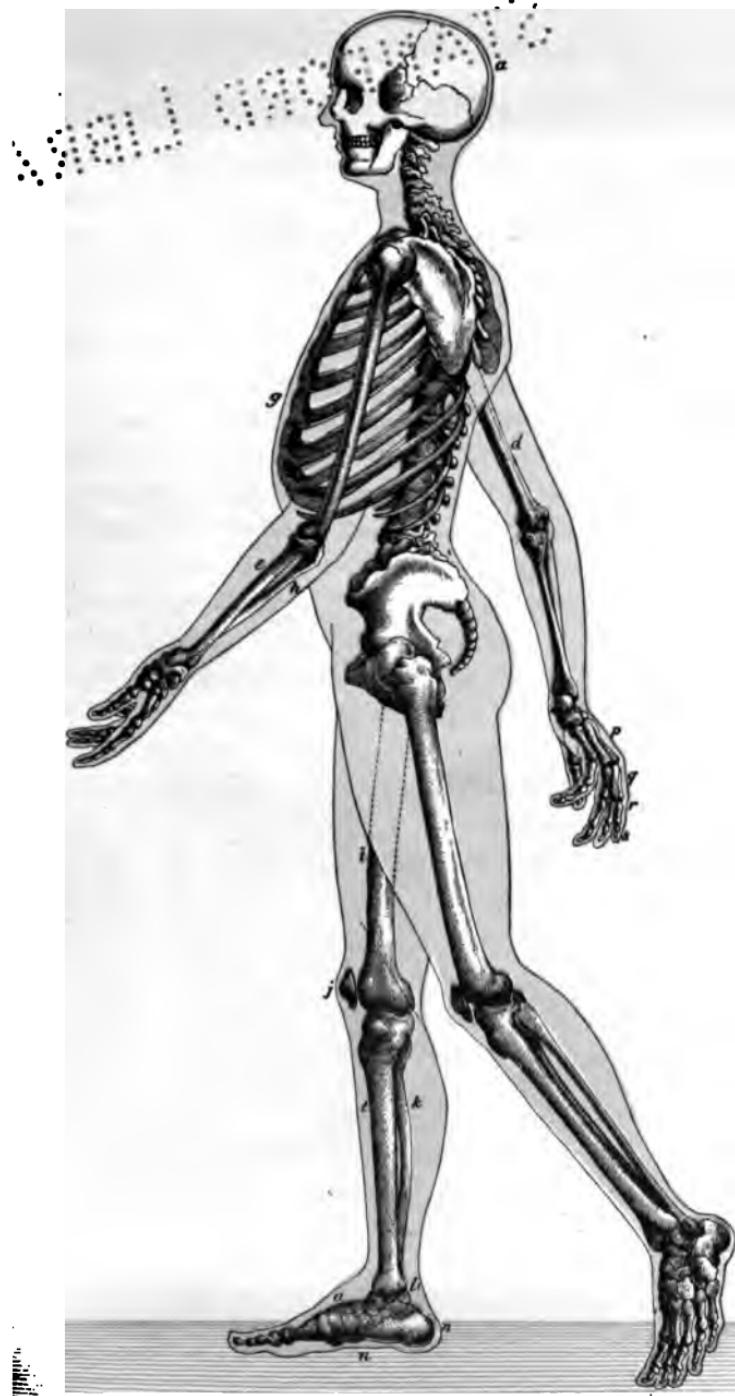
SCHOOL OF EDUCATION
LIBRARY







Stanford Library



FOURTEEN WEEKS

IN

HUMAN PHYSIOLOGY.

BY

J. DORMAN STEELE, PH. D.,

AUTHOR OF THE FOURTEEN-WEEKS SERIES IN NATURAL SCIENCE.

“T is the sublime of man,
Our noontide majesty—to know ourselves,
Part and proportion of a wondrous whole.”
COLERIDGE.



NEW YORK :: CINCINNATI :: CHICAGO

AMERICAN BOOK COMPANY

FROM THE PRESS OF
A. S. BARNES & CO.

592575

THE FOURTEEN-WEEKS SERIES



NATURAL SCIENCE,

BY

J. DORMAN STEELE, PH.D., F.G.S.

New Physics.

Human Physiology.

New Chemistry.

Zoology.

Popular Geology.

Botany

New Descriptive Astronomy.

Hygienic Physiology.

Hygienic Physiology, Abridged.

The Publishers can supply (to Teachers only) a Key containing Answers to the Questions and Problems in Steele's entire Series.

BARNES'S HISTORICAL SERIES,

ON THE PLAN OF

STEELE'S FOURTEEN-WEEKS IN THE SCIENCES.

A Brief History of the United States.

A Brief History of France.

A Brief History of Ancient Peoples.

A Brief History of Mediæval and Modern Peoples.

A Brief General History.

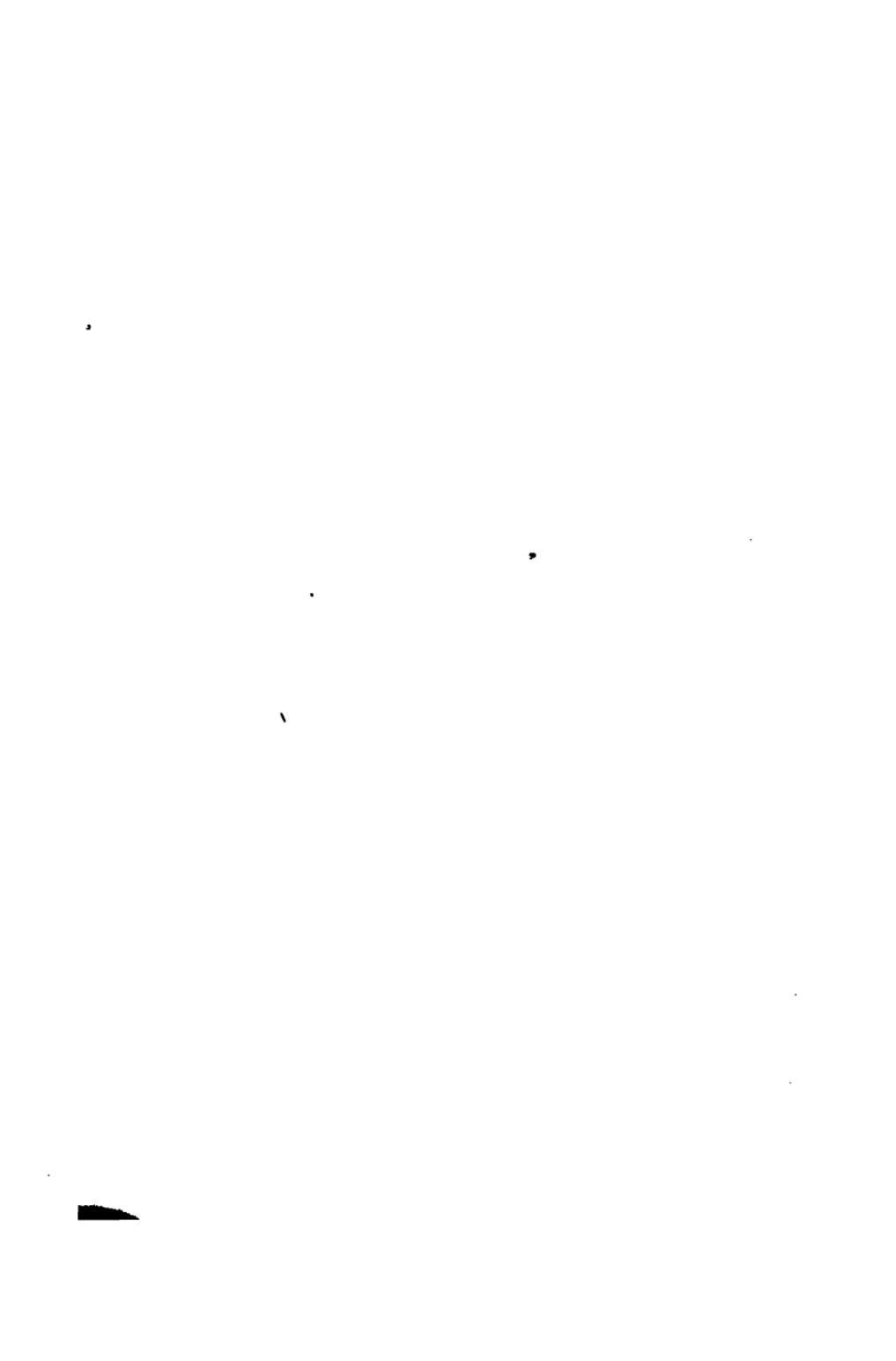
A Brief History of Greece.

A Brief History of Rome.

To

My Fellow-Teachers,

whose sympathy and co-operation have done so much to perfect this Series, and in lightening whose arduous labors the Author has felt a constant delight, this Volume is fraternally inscribed.



PREFACE.

HE term Physiology, or the science of the functions of the body, has come to include Anatomy, or the science of its structure, and Hygiene, or the laws of health ; the one being essential to the proper understanding of physiology, and the other being its practical application to life. The three are intimately blended, and in treating of the different subjects the author has drawn no line of distinction where nature has made none. This work is not prepared for the use of medical students, but for the instruction of youth in the principles which underlie the preservation of health and the formation of correct physical habits. All else is made subservient to this practical knowledge. A simple scientific dress is used which, while conducing to clearness, also gratifies that general desire of children to know something of the nomenclature of any study which they pursue.

To the description of each organ is appended an account of its most common diseases, accidents, etc., and, when practicable, their mode of treatment. A pupil may thus

learn, for example, the cause and cure of a cold, the management of a wound or the nature of an inflammation.

The Practical Questions, which have been a prominent feature of the series, will be found, it is hoped, equally useful in this work. Directions for preparing simple microscopic objects, and illustrations of the different organs, are given under each subject.

In the Appendix will be found Questions for class use, Hints about the sick-room, Suggestions as to what to do "till the doctor comes," Antidotes for poisons, and a full Index.

Believing in a Divine Architect of the human form, the author cannot refrain from occasionally pointing out His inimitable workmanship, and impressing the lesson of a Great Final Cause.

Great pleasure is taken in the acknowledgment of special obligations to William C. Wey, M.D., of Elmira, N. Y., President of the N. Y. State Medical Society, who has carefully read the work both in manuscript and in proof, and has added many valuable hints and illustrations.

The MS. was also reviewed by L. S. Burbank, A.M., Teacher of Natural Science, High School, Lowell, Mass., and the proofs by J. W. P. Jenks, A.M., Director of the Museum and Lecturer on Nat. Hist., Brown University; C. W. Parsons, M.D., Providence, R. I.; A. P. Stone, A.M., Prin. High School, Portland, Me.; S. G. Williams, Ph.D., Prin. High School, Cleveland, Ohio; C. H. Chandler, A.M.,

Springfield Republican, Springfield, Mass.; A. D. Small, A.M., Sup. Schools, Newport, R. I.; H. S. Jones, A.M., Sup. Schools, Erie, Pa.; William H. Beach, A.M., Prin. High School, and Sam'l Calvin, Prin. Grammar School No. 4, Dubuque, Iowa; L. C. Foster, Prin. Grammar School No. 1, Elmira, N. Y., and others, all of whom have enriched the book with the fruits of their experience.

The author has gleaned from every field, at home and abroad, to secure that which would interest and profit his pupils. In general, Flint's great work on the Physiology of Man, an undisputed authority on both sides of the Atlantic, has been adopted as the standard in digestion, respiration, circulation, and the nervous system. Leidy's Human Anatomy, and Sappey's *Traité d'Anatomie* have been followed on all anatomical questions, and have furnished many beautiful drawings. Huxley's Physiology (London, 1871), has afforded exceedingly valuable aid. Hinton's delightful work on Health and its Conditions, Black's valuable Ten Laws of Health, Williams's practical essay on Our Eyes and How to Use them, Le Pileur's charming treatise on The Wonders of the Human Body, and that quaint volume, Odd Hours of a Physician, have aided the author with facts and fancies. The writings of Draper, Dalton, Carpenter, Valentine, Mapother, Watson, Lankester, Letheby, Hall, Hamilton, Bell, Wilson, Bower, Cutter, Hutchison, Wood, Bigelow, Stillé, Holmes, Beigel and others have been freely consulted.

PUBLISHERS' NOTICE.

THE HYGIENIC PHYSIOLOGY, a revision of this work, is now ready. It contains much new matter, such as Blackboard Analyses, a chapter on Ventilation, and also, interwoven through the text, a careful treatment of the physiological influence of alcohol, tobacco, opium, and other narcotics. This is the only work of academic grade that has the approval of the Women's Christian Temperance Union.

SUGGESTIONS TO TEACHERS.



SEEING is believing ;—more than that ; it is often knowing and remembering. The mere reading of a statement is of little value compared with the observation of a fact. Every opportunity should therefore be taken of exhibiting to the pupil the phenomena described, and thus making them real. A microscope is so essential to the understanding of many subjects, that it is indispensable to the proper teaching of Physiology. A suitable instrument and carefully prepared specimens showing the structure of the bones, the skin, and the blood of various animals, the pigment cells of the eye, etc., may be obtained at a small cost from the Publishers of this book. They also keep for sale models of all the organs. These were prepared under the supervision of Dr. Bock, Prof. of Anatomy in the University of Leipsic, and will be found exceedingly valuable.

On naming the subject of a paragraph, the pupil should be prepared to tell all he knows about it. No failure should discourage the teacher in establishing this mode of study and recitation. A little practice will produce the

most satisfactory results. The unexpected question and apt reply develop a certain sharpness and readiness which are worthy of cultivation. The questions for review, or any others which the wit of the teacher may suggest, can be effectively used to break the monotony of a topical recitation, thereby securing the benefits of both systems.

The pupil should expect to be questioned each day upon any subject passed over during the term, and thus the entire knowledge gained will be within his grasp for instant use. While some are reciting to the teacher, let others write on slates or on the blackboard. At the close of the recitation let all criticise the ideas, the spelling, the use of capitals, the pronunciation, the grammar and the mode of expression. Greater accuracy and much collateral drill may thus be secured at little expense of valuable school-time.

The Introduction is designed merely to furnish suggestive material for the first lesson, preparatory to beginning the study. Other topics may be found in the questions given in the Appendix.

Note.—Interest in the study of Physiology will be much increased by the use of the microscope and prepared slides. By writing to the publishers of this book, full particulars will be furnished.

TABLE OF CONTENTS.

	PAGE
<i>INTRODUCTION</i>	15
I.	
<i>THE SKELETON</i>	19
II.	
<i>THE MUSCLES</i>	43
III.	
<i>THE SKIN</i>	61
IV.	
<i>RESPIRATION AND THE VOICE</i>	83
V.	
<i>THE CIRCULATION</i>	105
VI.	
<i>DIGESTION AND FOOD</i>	188
VII.	
<i>THE NERVOUS SYSTEM</i>	189

	VIII.	PAGE
<i>THE SPECIAL SENSES</i>	179	
1. <i>TOUCH</i>	179	
2. <i>TASTE</i>	181	
3. <i>SMELL</i>	182	
4. <i>HEARING</i>	184	
5. <i>SIGHT</i>	187	
IX.		
<i>CONCLUSION</i>	197	
X.		
<i>APPENDIX</i>	203	
1. <i>HINTS ABOUT THE SICK-ROOM</i>	203	
2. <i>DISINFECTANTS</i>	204	
3. <i>WHAT TO DO "TILL THE DOCTOR COMES"</i>	204	
4. <i>ANTIDOTES TO POISONS</i>	209	
5. <i>QUESTIONS FOR CLASS USE</i>	211	
6. <i>ANALYSIS OF THE SKELETON</i>	230	
7. <i>INDEX</i>	233	

INTRODUCTION.



PHYSIOLOGICAL STUDY in youth is of inestimable value. Precious lives are frequently lost through ignorance. Thousands squander in early years the strength which should have been kept for the work of real life. Habits are often formed in youth which entail weakness and poverty upon manhood and are a cause of life-long regret. The use of a strained limb may permanently damage it. Some silly feat of strength may produce an irreparable injury. A thoughtless hour of reading by twilight may impair the sight for life. A terrible accident may happen, and a dear friend perish before our eyes, while we stand by powerless to render the assistance we could so easily give did we "only know what to do." The thousand little hints which may save or lengthen life, may repel or abate disease, or the simple laws which regulate our bodily vigor, should be so familiar that we may be quick to apply them in an emergency. The preservation of health is easier than the cure of disease. Childhood cannot afford to wait for the lesson of experience which is learned only when the penalty of violated law has been already incurred, and health irrevocably lost.

Nature's Laws Inviolable.—In infancy we learn how terribly nature punishes a violation of certain laws, and how promptly she applies the penalty. We soon find out

the peril of fire, falls, edged-tools, and the like. We fail, however, to notice the equally sharp and certain punishments which bad habits entail. We are quick to feel the need of food, but not so ready to perceive the danger of an excess. A lack of air drives us at once to secure a supply; but foul air is as fatal, yet gives us no warning. Nature provides a little training for us at the outset of life, but leaves the most for us to learn by bitter experience. So in youth we throw away our strength as if it were a burden of which we desired to be rid. We eat anything, and at any time; do anything we please, and sit up any number of nights with little or no sleep. Because we feel only a momentary discomfort from these physical sins, we fondly imagine when that is gone we are all right again. Our drafts upon our constitution are promptly paid, and we expect this will always be the case; but some day they will come back to us protested; nature will refuse to meet our demands, and we shall find ourselves physical bankrupts. We are furnished in the beginning with a certain vital force upon which we may draw. We can be spendthrifts and waste it in youth, or be wise men and husband it to manhood. Our shortcomings are all charged against this stock. Nature's memory never fails; she keeps the account with perfect exactness. Every physical sin subtracts from the sum and strength of our years. We may cure a disease, but it never leaves us as it found us. We may heal a wound, but the scar still shows. We reap as we sow, and we may either gather in the thorns, one by one, to torment and destroy, or rejoice in the happy harvest of a hale old age.

I.

THE SKELETON.

“Not in the world of light alone,
Where God has built His blazing throne,
Nor yet alone on earth below,
With belted seas that come and go,
And endless isles of sunlit green,
Is all thy Maker’s glory seen—
Look in upon thy wondrous frame,
Eternal wisdom still the same !”

HOLMES.



THE SKELETON.

THE **Skeleton**, or framework, of the “House we live in,” is composed of about 200 bones.*

Uses and Forms of the Bones.—They have three principal uses: 1. To protect the delicate organs; † 2. To serve as levers on which the muscles may act to produce motion; and 3. To preserve the shape of the body. Bones differ in form according to the uses they subserve. For convenience in walking, some are long; for strength and compactness, some are short and thick; for covering a cavity, some are flat; and for special purposes, some are irregular. The general form is such as to combine strength and lightness. For example, all the long bones of the

* The precise number varies in different periods of life. Several which are separated in youth become united in old age. Thus five of the vertebre early join in one great bone—the sacrum, and four tiny ones below it often run into a bony mass—the coccyx (Fig. 6). (See Analysis of the Skeleton in the Appendix, page 280.)

While, however, the number of the bones is so uncertain, their relative length is so exact that the length of the entire skeleton, and thence the height of the man, can be obtained by measuring a single one of the principal bones. Fossil bones and those found at Pompeii have the same proportion as our own.

† An organ is a portion of the body designed for a particular use, which is called its *function*. Thus the heart circulates the blood, the liver produces the bile.

limbs are round and hollow, thus giving with the same weight a greater strength,* and also a larger surface for the attachment of the muscles.

The Composition of the Bones at maturity is about one part animal to two parts mineral matter. The proportion varies with the age. In youth it is nearly half and half, while in old age the mineral is greatly in excess. By soaking a bone in weak muriatic acid, and thus dissolving the mineral matter, its shape will not change, but its stiffness will disappear, leaving a tough, gristly substance † (cartilage), which can be bent like rubber.

If the bone be burned in the fire, thus consuming the animal matter, the shape will still be the same, but it will have lost its tenacity, and the beautiful, pure-white residue ‡ may be crumbled into powder with the fingers.

* Cut a sheet of foolscap in two pieces. Roll one-half into a compact cylinder, and fold the other into a close, flat strip; support the ends of each, and hang weights in the middle until they bend. The superior strength of the roll will astonish one unfamiliar with this mechanical principle. In a rod, the particles break in succession, first those on the outside, and later those in the centre. In a tube, the particles are all arranged where they resist the first strain. Iron pillars are therefore cast hollow. Stalks of grass and grain are so light as to bend before a breath of wind, yet are stiff enough to sustain their load of seed.

Bone is twice as strong as oak. It would require a weight of 5000 lbs. to crush a cubic inch.—MAPOTHEC.

† Mix a wineglass of muriatic acid with a pint of water and place in it a sheep's rib. In a day or two it will be so soft that it can be tied in a knot. In the same way an egg may be made so pliable that it can be crowded into a narrow-necked bottle, within which it will expand and become an object of great curiosity to the uninitiated.

By boiling bones at a high temperature, the animal matter separates in the form of gelatin or glue, and is used for soups and jellies. Dogs and cats extract the animal matter from the bones which they eat. Fossil bones deposited in the ground before the creation of man, were found by Cuvier to still contain considerable animal matter. Gelatin was actually extracted from the Cambridge mastodon, and made into glue. A tolerably nutritious food might thus be manufactured from bones older than man himself.

‡ From bones thus calcined, the phosphorus of the chemist is made. See *Chemistry*, page 120. If the animal matter be not consumed, but only charred, the bone will be black and brittle. In this way the "bone-black" of commerce is manufactured.

We thus see that a bone receives hardness and rigidity from its mineral, and tenacity and elasticity from its animal matter.

The entire bone is at first composed of cartilage, which gradually *ossifies* or turns to bone.* Certain portions near the joints are long delayed in this process, and by their elasticity assist in breaking the shock of a fall.† Hence the bones of children are tough, are not readily fractured, and when broken easily heal again; while those of elderly people are liable to fracture, and do not quickly unite.

The Structure of the Bones.—When a bone is sawed lengthwise, it is

* The ossification of the bones on the sides and upper part of the skull, for example, begins by a rounded spot in the middle of each one. From this spot the ossification extends outward in every direction, thus gradually approaching the edges of the bone. When two adjacent bones meet, therefore, there will be a line where their edges are in contact with each other, but have not yet united; but when more than two bones meet in this way, there will be an empty space between them at their point of junction. Thus, if you lay down three coins upon the table with their edges touching each other, there will be a three-sided space in the middle between them; if you lay down four coins in the same manner, the space between them will be four-sided. Now at the back part of the head there is a spot where three bones come together in this way, leaving a small three-sided opening between them: this is called the "posterior fontanelle." On the top of the head four bones come together, leaving between them a large four-sided opening: this is called the "anterior fontanelle."

These openings are termed the *Fontanelles*, because we can feel the pulsations of the brain through them, like the bubbling of water in a fountain. The fontanelles gradually diminish in size, owing to the growth of the bony parts around them, and are completely closed at the age of four years after birth.—DALTON's *Physiology*, p. 361.

† Frogs and toads, which move by jumping, and consequently receive so many jars, retain these unossified portions nearly through life; while alligators and turtles, whose position is sprawling, and whose motions are measured, do not have them at all.—LEHDY.

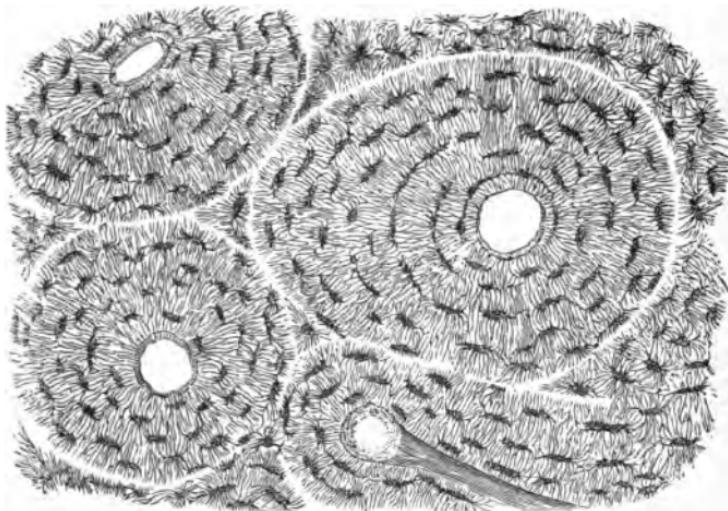
Fig. 2.



The thigh-bone or femur, sawed lengthwise.

found to be a compact shell filled with a spongy substance. This filling increases in quantity, and becomes more porous at the ends of the bone, thus giving greater size to form a strong joint, while the solid portion increases near the middle, where strength alone is needed. Each fibre of this bulky material diminishes the shock of a sudden blow, and also acts as a beam to brace the exterior wall.

Fig. 3.



A thin slice of bone, highly magnified, showing the lacunæ, the tiny tubes (canalliculi) radiating from them, and four Haversian canals, three seen crosswise and one lengthwise.

In the body, bones are not the dry, dead, blanched things they seem to be, but are moist, living, pinkish structures, covered with a tough membrane called the *peri-o-s'-te-um*,*

* The relations of the periosteum to the bone are very interesting. Instances are on record where the bone had been removed, leaving the periosteum, from which the entire bone was afterward renewed.

(*peri*, around, and *osteon*, a bone), and the hollow filled with marrow, rich in fat and full of blood-vessels. If we examine a thin slice with the microscope, we shall see black spots with lines running in all directions, and looking very like minute insects. These are really little cavities called *la-cú-næ*,* from which radiate tiny tubes. The lacuna are arranged in circles around larger tubes, termed from their discoverer, *Haversian canals*, which serve as passages for the blood-vessels which supply the bone. The outer ends of the canals connect with the blood-vessels of the periosteum, and, if the bone is hollow, the inner ends, with those of the marrow.

Growth of the Bones.—By means of this system of canals, the blood circulates as freely through the bones as any part of the body. The whole structure is constantly but slowly changing,† old material being taken out and new put in. A curious illustration is seen in the fact that if madder be mixed with the food of pigs, it will tinge their bones red.

Repair of the Bones.—When a bone is broken, the blood at once oozes out of the fractured ends. This soon gives place to a watery fluid, which in a fortnight thickens to a gristly substance strong enough to hold them in place. Bone-matter is then slowly deposited, which in five or six weeks will unite the broken parts. Nature, at first, apparently endeavors to remedy the weakness of the material by excess in the quantity, and so the new portion is larger than

* When the bone is dry, the lacunæ are filled with air, which refracts the light, so that none of it reaches the eye.

† Bone is sometimes produced with surprising rapidity. The great Irish Elk is calculated by Prof. Owen to have cast off and renewed annually in its antlers eighty pounds of bone.

the old. But the extra matter will be gradually absorbed, sometimes so perfectly as to leave no trace of the injury. A broken limb should always be held in place by splints to enable this process to go on uninterruptedly, and also lest a sudden jar might rupture the partially mended break. For a long time the new portion consists largely of animal matter, and so is tender and pliable. The utmost care is therefore necessary to prevent a malformation.

The Joints are packed with a soft, smooth cartilage or gristle, which fits so perfectly as often to be air-tight. Upon convex surfaces it is thickest at the middle, and upon concave, at the edge, or where the wear is greatest. In addition, the ends of the bones are covered with a thin membrane, the *synovial* (*sun*, with; *ovum*, an egg), which secretes a viscid fluid, not unlike the white of an egg. This lubricates the joints, and prevents the noise and wear of friction. The body is the only machine that oils itself.

The bones which form the joint are tied with stout ligaments (*ligo*, I bind), or bands of a smooth, silvery white tissue,* so strong that the bones are sometimes broken without injuring the fastenings.

Classification of the Bones.—For convenience the bones of the skeleton are considered in three divisions: the *head*, the *trunk*, and the *limbs*.

* The general term *tissue* is applied to the various textures of which the organs are composed. For example, the *osseous* tissue forms the bones; the fibrous tissue, the muscles.

THE HEAD.

Fig. 4.



The Skull.—1, frontal bone; 2, parietal bone; 3, temporal bone; 4, the sphenoid bone; 5, ethmoid bone; 6, superior maxillary (upper jaw) bone; 7, malar bone; 8, lachrymal bone; 9, nasal bone; 10, inferior maxillary (lower jaw) bone.

The Bones of the Skull and the Face form a cavity for the protection of the brain and four organs of sense, viz.: sight, smell, taste, and hearing. All of these bones are immovable except the lower jaw, which is hinged * at the back so as to allow the opening and shutting of the mouth.

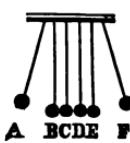
The Skull is composed of two compact plates, with

* A ring of cartilage is inserted in its joints, something after the manner of a washer in machinery. This follows the movements of the jaw, and admits of freer motion, while it guards against dislocation.

a spongy layer between. These are in several pieces, the outer ones being joined by notched edges (sutures, *süt'-yurs*) in the way carpenters term dove-tailing. (See Figs. 1, 4.) The peculiar structure and form of the skull afford a perfect shelter for the brain—an organ so delicate that, if unprotected, an ordinary blow falling upon it would destroy it forever. Its oval or egg shape adapts it to resist pressure. The smaller and stronger end is in front, where the danger is greatest. Projections before and behind shield the less protected parts. The hard plates are not easy to penetrate.* The spongy packing deadens every blow.† The separate pieces with their curious joinings disperse any jar which one may receive, and also prevent fractures from spreading. The frequent openings in this strong bone-box afford safe avenues for the passage of numerous nerves and arteries which serve as a means of communication between the brain and the rest of the body.

* Instances have been known where bullets striking against the skull have glanced off, been flattened, or even split into halves. In the Peninsular Campaign, the author saw a man who had been struck in the forehead by a bullet which, instead of penetrating the brain, had followed the skull around to the back of the head, and there passed out.

Fig. 5.



† An experiment resembling the familiar one of the balls in Natural Philosophy (see Physics, Figure 7, page 30), beautifully illustrates this point. Several balls of ivory are suspended by cords, as in Fig. 5. If A be raised and then let fall, it will transmit the force to B, and that to C, and so on until F is reached, which will fly off with the impulse. If now a ball of spongy bone be substituted for an ivory one anywhere in the line, the force will be checked, and the last ball will not stir.

Fig. 6

THE TRUNK.

The Trunk has two important cavities. The upper part, or *chest*, contains the heart and the lungs, and the lower part, or *abdomen*, holds the stomach, liver, kidneys and other organs. (See Fig. 31.) The principal bones are those of the *spine*, the *ribs*, and the *hips*.

The Spine consists of twenty-four bones, between which are placed pads of cartilage.* A canal is hollowed out of the column for the safe passage of the spinal cord. (See Fig. 48.) Projections (processes) at the back and on either side are abundant for the attachment of the muscles. The packing acts as a cushion to prevent any jar from reaching the brain when we jump or run, while the double curve of the spine also tends to disperse the force of a fall. Thus on every side the utmost caution is taken to guard that precious gem in its casket.

The Perfection of the Spine surpasses all human contrivances. Its va-

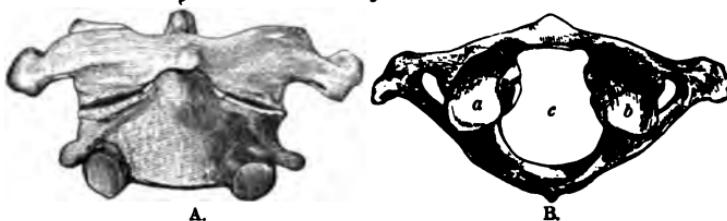


The Spine ; 7 vertebrae of the neck, cervical ; 12 of the back, dorsal ; 5 of the loins, lumbar ; a, the sacrum ; b, the coccyx.

* These pads vary in thickness from one-fourth to one-half an inch. They become condensed by the weight they bear during the day, so that we are somewhat shorter at evening than in the morning. Their elasticity causes them to resume their usual size during the night, or when we lie down for a time.

rious uses seem a bundle of contradictions. A chain of twenty-four bones is made so stiff that it will bear a heavy burden, and so flexible that it will bend like rubber; yet, all the while, transmits no shock, and even hides within it a delicate nerve that would thrill with the slightest touch. Resting upon it, the brain is borne without a tremor; and clinging to it, the vital organs are carried without fear of harm.

Fig. 7.



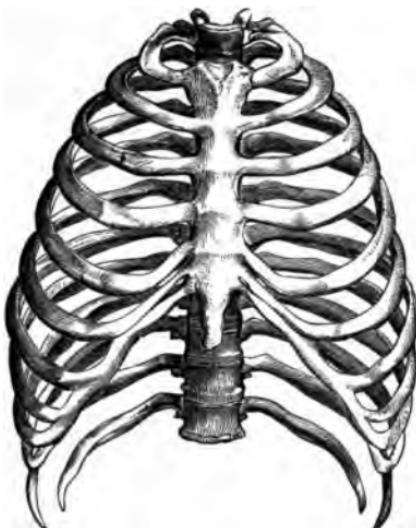
B, the atlas; A, the atlas and axis.

The Skull Articulates with (is jointed to) the spine in a peculiar manner. On the top of the upper vertebra (atlas *) are two little hollows (*a, b*, Fig. 7), nicely packed and lined with the synovial membrane, into which fit the corresponding projections on the lower part of the skull, and thus the head can rock to and fro. The second vertebra (axis) has a peg, *e*, which projects through a hole, *c*, in the first. The surfaces of both vertebrae are so smooth that they easily glide on each other, and thus, when we move the head sidewise, the atlas turns around the peg, *e*, of the axis.

The Ribs, also twenty-four in number, are arranged in

* So called because, as in ancient fable, the god Atlas supported the world on his shoulders, so in the body this bone bears the head.

Fig. 8.



The Chest.

pairs on each side of the chest. At the back they are all attached to the spine. In front, the upper seven pairs are tied by cartilages to the breast-bone (sternum); three are fastened to each other and the cartilage above, and two, the floating ribs, are loose. The natural form of the chest would be that of a cone diminishing upward. Owing to the tightness of the clothing as commonly worn, the reverse is often the case. The long, slender ribs give lightness,* the arched form confers strength, and the cartilages impart elasticity—properties essential to the protection of the delicate organs within, and to freedom of motion in respiration.

* If the chest-wall were in one bone, thick enough to resist a blow, it would be unwieldy and heavy. As it is, the separate bones bound by cartilages yield gradually, and diffuse the force among them all, and so are rarely broken.

Fig. 9.



The Pelvis: a, the sacrum.

The Hip-bones, called by anatomists the *Innominata*, or nameless bones, form an irregular basin styled the *pelvis* (*pelvis*, a basin). In the upper part is the foot of the spinal column and a wedge-shaped bone termed the *sacrum** (sacred), firmly planted here between the wide-spreading and solid bones of the pelvis, like the keystone to an arch, and giving a steady support to the heavy burdens above.



THE LIMBS.

Two Sets of Limbs branch from the trunk, viz.: the upper and the lower. They closely resemble each other. The arm corresponds to the thigh, the forearm to the leg, the wrist to the ankle, the fingers to the

* So called because it was anciently offered in sacrifice.

toes. The fingers and toes are so much alike that they receive the same name, *digits*, while the several bones of both have also the common appellation, *phalanges*. The differences which exist grow out of their varying uses. The foot is characterized by strength, the hand by mobility.

The Upper Limbs.—The Shoulder.—The bones of the shoulder are the collar-bone (clavicle), and the shoulder-blade (scapula). The *clavicle* (*clavis*, a key) is a long, slender bone, shaped like the Italic *f*. It is fastened at one end to the breast-bone and the first rib, and at the other, to the shoulder-blade. (See Fig. 1.) It thus holds the shoulder-joint out from the chest and gives the arm greater play. If it be removed or broken, the head of the arm-bone will fall, and the motions of the arm be greatly restricted.*

The Shoulder-blade is a thin, flat, triangular bone, fitted to the top and back of the chest, and designed to give a foundation for the muscles of the shoulder.

The Shoulder-joint.—The arm-bone, or *humerus*, articulates with the shoulder-blade by a ball-and-socket joint. This consists of a cup-like cavity in the latter bone, and a rounded

Fig. 10.

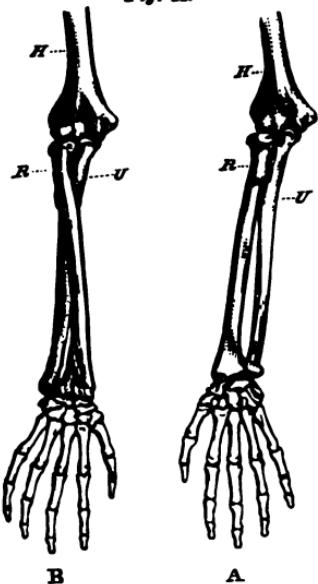
a



The Shoulder-joint: a, the clavicle; b, the scapula.

* Animals which use the forelegs only for support, do not possess this bone.—LEIDY.

Fig. 11.



Bones of the right Forearm: H., the humerus; R., the radius; and U., the ulna.

bone of the forearm is, on the contrary, small at its upper end, and enters but little into the elbow-joint, while it is large at its lower end and constitutes the greater part of the wrist-joint. At the elbow, the head of the radius is convex and fits into a shallow cavity in the ulna, while at the wrist the ulna plays in a similar socket in the radius. Thus the radius may roll over and even cross the ulna.

The Wrist, or *carpus*, consists of two rows of very irregular bones; one of which articulates with the arm, and the other with the hand. They are placed side to side and so firmly fastened as to admit of only a gliding motion. This gives little play, but great strength, elasticity, and power of resisting shocks.

head in the former, to fit it,—thus affording a free rotary motion. The shallowness of the socket accounts for the frequent dislocation of this joint, but a deeper one would diminish the easy swing of the arm.

The Elbow.—At the elbow the humerus articulates with the *ulna*—a slender bone on the inner side of the forearm—by a hinge-joint which admits of motion in only two directions, i. e., backward and forward. The *ulna* at its lower end is small, and assists but slightly in forming the wrist-joint. The *radius*, or large

The Hand.—The *metacarpal* (*meta*, beyond, and *karpos*, wrist), or bones of the palm, support each a thumb or finger. The first bone of the thumb, standing apart from the rest, enjoys a special freedom of motion, and adds greatly to the usefulness of the hand. The first bone (Figs. 11, 12) of each finger is so attached to the corresponding metacarpal bone as to move in several directions upon it, but the other phalanges form hinge-joints. The fingers are named in order: the thumb, the index, the middle, the ring, and the little finger. Their different lengths cause them to fit the hollow of the hand when it is closed, and probably enable us more easily to grasp objects of varying size. If the hand clasps a ball, the tips of the fingers will be in a straight line.

The hand in its perfection belongs only to man. Its elegance of outline, delicacy of mould, and beauty of color, have made it the study of artists; while its exquisite mobility, and adaptation as a perfect instrument, have led many philosophers to attribute man's superiority even more to the hand than to the mind.*

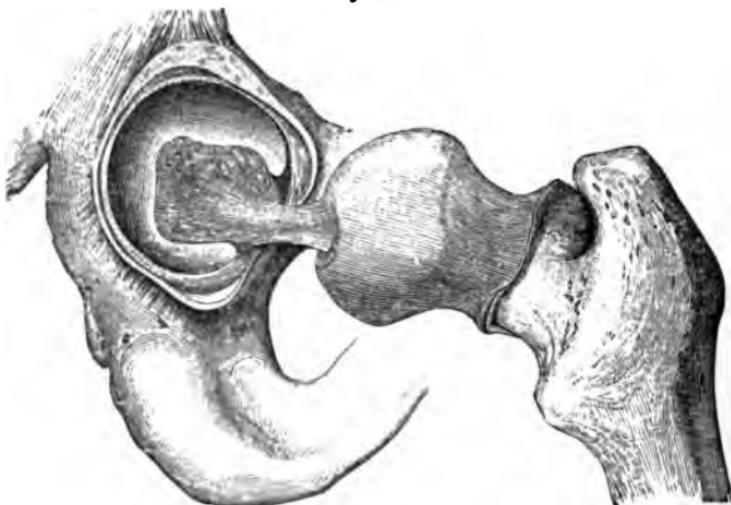
Fig. 12.



Bones of the Hand and the Wrist.

* How constantly the hand aids us in explaining or enforcing a thought! We affirm a fact by placing the hand as if we would rest it firmly on a body; we deny by a gesture putting the false or erroneous proposition away from us;

Fig. 12.



The Hip-joint.

The Lower Limbs.—The Hip.—The thigh-bone, or *femur*, is the largest and necessarily the strongest in the skeleton, since at every step it has to bear the weight of the whole body. It articulates with the hip-bone by a “ball-and-socket” joint. Unlike the shoulder-joint, the cup here is deep, thus affording less play but greater strength. It fits so tightly that the pressure of the air largely aids in keeping the bones in place.* Indeed, when the muscles

we express doubt by holding the hand suspended, as if hesitating whether to take or reject. When we part from dear friends, or greet them again after long absence, the hand extends toward them as if to retain, or to bring them sooner to us. If a recital or a proposition is revolting, we reject it energetically in gesture as in thought. In a friendly adieu we wave our good wishes through space to him who is the object of them; but when it expresses enmity, by a brusque movement we sever every tie. The open hand is carried backward to express fear or horror, as well as to avoid contact; it goes forward to meet the hand of friendship; it is raised suppliantly in prayer toward Him from whom we hope for help; it caresses lovingly the downy cheek of the infant, and rests on its head invoking the blessing of Heaven.—*Wonders of the Human Body.*

* To prove this, a hole was bored through the hip-bone so as to admit air into

are all cut away, very great force is required to detach the limb.

The Knee is strengthened by the *patella*, or knee-pan (*patella*, little dish), a chestnut-shaped bone firmly fastened over the joint. The shin-bone, or *tibia*, the large triangular bone on the inner side of the leg, articulates both with the femur and the foot by a hinge-joint. The knee-joint is so made, however, as to admit of a slight rotary motion when the limb is not extended. The *fibula* (*fibula*, a clasp), the small outside bone of the leg, is firmly bound at both ends to the tibia. (See Fig. 1.) It is immovable, and as the tibia bears the principal weight of the body, the chief use of this second bone seems to be to give more surface to which the muscles may be attached.*

The Foot.—The general arrangement of the foot is strikingly like that of the hand. The several parts are the tarsus, the metatarsus, and the phalanges. The graceful arch of the foot, and the numerous bones joined by cartilages, give an elasticity to the step which could never be attained by a single, flat bone. The toes naturally lie

the socket, when the thigh-bone at once fell out as far as the ligaments would permit. An experiment was also devised whereby a suitably prepared hip-joint was placed under the receiver of an air-pump. On exhausting the air the weight of the femur caused it to drop out of the socket, while the re-admission of the air raised it to its place.

Without this arrangement, the adjacent muscles would have been compelled to bear the additional weight of the thigh-bone every time it was raised. Now the pressure of the air rids them of this useless burden, and hence they are less easily fatigued.—WEBER.

* A young man in the hospital at Limoges had lost the middle part of his tibia. The lost bone was not reproduced, but the fibula, the naturally weak and slender part of the leg, became thick and strong enough to support the whole body.—CRUVELLIER.

An experiment has been performed which illustrates this idea still more strikingly. An inch of the middle part of the fibula of an animal was cut out. A long time afterward the beast was killed, when the tibia was found to have become considerably larger in that part of it which corresponded exactly with the defect in the fibula.—STANLEY'S *Lectures*.

straight forward in the line of the foot. As we step with the bare foot, the ball receives the weight first, the sole broadens and lengthens, the toes spread, the muscles all come in play with the arch of the instep, diffusing and breaking the jar; the heel then settles down under the final burden, and affords a firm support.

Few persons in civilized nations, however, have naturally-formed feet. The big toe is crowded upon the others, while crossed toes, nails grown-in, enormous joints, corns and bunions abound.

The Cause of these Deformities is found in the shape and size of fashionable boots and shoes. The sole ought to be large enough for full play of motion, the uppers should not crowd the toes, and the heels should be low, flat, and broad. As it is, there is a constant warfare between Nature and our shoemakers,* and we are the victims. The narrow point in front pinches our toes and compels them to override one another; the narrow sole compresses the arch; while the high heel, by throwing all the weight forward on the toes, strains the ankle, and by sending the pressure where Nature did not design it to fall, causes that joint to become enlarged. The body bends forward to meet the demand of this new motion, and thus loses its uprightness and beauty, making our whole gait stiff and ungraceful.

Diseases, etc.—1. *The Rickets* are caused by a lack of mineral matter in the bones, rendering them soft and pliable, so that they bend under the weight of the

* When we are measured for boots or shoes, we should *stand* on a sheet of paper and have the shoemaker mark with a pencil the exact outline of our feet as they bear our whole weight. When the shoe is made, the sole should exactly cover this outline.

body. They thus become permanently distorted, and of course are weaker than if they were straight.* The disease is cured by a more nutritive diet or by taking phosphate of lime to supply the lack.

2. *A Felon* is a swelling of the finger or thumb, usually of the last joint. It is marked by an accumulation of matter beneath the periosteum and next the bone. It should be opened so as to prevent the poison collected there from being absorbed and thus scattered through the system. The physician will merely cut through the periosteum and let out the effete matter.

3. *Bowlegs* are caused by children standing on their feet before the bones of the lower limbs are strong enough to bear their weight. The custom of encouraging young children to stand up by means of a chair or the support of the hand while the bones are yet soft and pliable is a cruel one, and liable to produce permanent deformity. Nature will set the child on its feet when the proper time comes.

4. *Curvature of the Spine*.—When the spine is bent, the packing between the vertebrae becomes compressed on one side into a wedge-like shape. After a time it will lose its elasticity, and the spine become distorted. This occurs frequently in the case of students who bend forward to bring their eyes nearer their books, instead of lifting their books nearer their eyes, or who raise their right shoulder above their left when writing at a desk

* Just here appears an exceedingly beautiful provision. As soon as the disproportion of animal matter ceases, a larger supply of mineral is sent to the weak points, and the bones actually become thicker, denser, harder, and consequently stronger at the very concave part where the stress of pressure is greatest.—*Watson's Lectures on Physic*.

We shall often have occasion to refer to similar wise and providential arrangements whereby the body is enabled to remedy defects, and prepare for accidents.

which is too high. Round shoulders, small, weak lungs, and, oftentimes, diseases of the spine are the consequences. An erect posture in reading or writing conduces not alone to beauty of form, but also to health of body.

5. *Sprains* are produced when the ligaments which bind the bones of a joint are strained, twisted, or torn from their attachments. They are quite as harmful as a broken bone, and require careful attention lest they lead to a crippling for life. The use of a sprained limb may permanently impair its usefulness. Hence, the joint should be kept quiet, even after the immediate pain is gone.

6. *A Dislocation* is the forcible displacement of a bone from its socket. It is, generally, the result of a fall or a violent blow. The tissues of the joint are often ruptured, while the contraction of the muscles prevents the easy return of the bone to its place.

PRACTICAL QUESTIONS.

1. Why does not a fall hurt a child as much as it does a grown person?
2. Should a young child ever be urged to stand or walk?
3. What is meant by "breaking one's neck?"
4. Should chairs or benches have straight backs?
5. Should a child's feet be allowed to dangle from a high seat?
6. Why can we tell whether a fowl is young by pressing on the point of the breast-bone?
7. What is the use of the marrow in the bones?
8. Why is the shoulder so often put out of joint?
9. How can you tie a knot in a bone?
10. Why are high pillows injurious?
11. Is the "Grecian bend" a healthful position?
12. Should a boot have a heel-piece?
13. Why should one always sit and walk erect?
14. Why does a young child creep rather than walk?
15. What would be the natural direction of the big toe?

II.

THE MUSCLES.

“BEHOLD the outward moving frame,
Its living marbles jointed strong,
With glistening band and silvery thong,
And link'd to reason's guiding reins,
By myriad rings in trembling chains,
Each graven with the threaded zone
Which claims it as the Master's own.”

HOLMES



A 3D ribbon plot showing a helical structure composed of small spheres, forming a twisted ladder-like shape. The plot is rendered in a perspective view, showing the helix winding around a central axis. The spheres are small and dark, creating a sense of depth and volume. The overall shape is a complex, twisted helix.



THE MUSCLES.

THE **Use of the Muscles.**—The skeleton is the image of death. Its unsightly appearance instinctively repels us. We have seen, however, what uses it subserves in the body, and how the ugly-looking bones abound in nice contrivances and ingenious workmanship. In life, the framework is hidden by the flesh. This covering is a mass of muscles, which not only give form and symmetry to the body, but also produce its varied movements. In Fig. 14 we see the large exterior muscles. Beneath these are many others; while deeply hidden within are tiny, delicate ones, too small to be seen with the naked eye. There are, in all, about five hundred, each having its special use, and all working in exquisite harmony and perfection. The peculiar property of the muscles is their power of contraction, whereby they decrease in length and increase in thickness.

Arrangement of the Muscles.—The muscles are arranged in pairs,* each with its antagonist, so that as they

* "There are only twelve single muscles in the body."

Fig. 26.



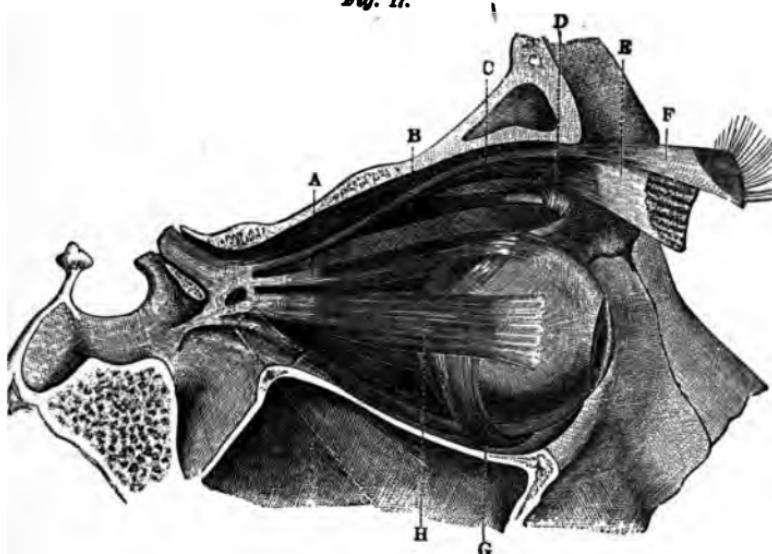
Tendons of the Hand.

be made and thus the beauty of the slender joint be marred. To prevent this, a stout band or bracelet of ligament holds them down to their place. 2. In order to allow the tendon which moves the last joint of the finger to pass through, the tendon which moves the second joint divides at its attachment to the bone. (Fig. 16.) This is the most economical mode of packing the muscles, as any other practicable arrangement would increase the bulk of the slender finger. Since the tendon cannot always pull in the direction of the desired motion, some contrivance is necessary to meet the want. The tendon (B) belonging to one of the muscles of the eye, for example, passes through a ring of cartilage, and thus a rotary motion is secured.

The Levers of the Body.*—In producing the motions of the body the muscles use the bones as levers. We

* A *lever* is a stiff bar resting on a point of support, called the *fulcrum* (F), and having connected with it a *weight* (W) to be lifted, and a *power* (P) to move it. There are three classes of levers according to the arrangement of the power, weight, and fulcrum. In the 1st class the F is between the P and W; in the 2d, the W is between the P and F; and in the 3d, the P is between the W and F (Fig. 18). A pump-handle is an example of the first, a lemon-squeezer of the second, and a pair of fire-tongs of the third.—See *Physics*, pp. 69–71, for a full description of this subject, and many illustrations.

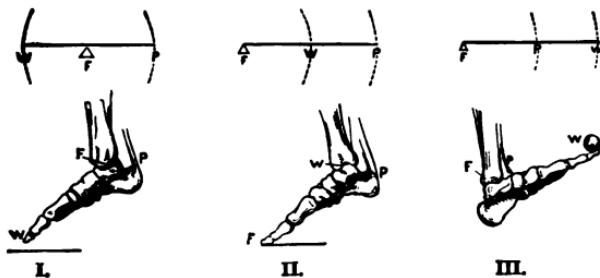
Fig. 17.



The Muscles of the Right Eye. A, superior straight; B, superior oblique passing through a pulley, D; G, inferior oblique; H, external straight, and, back of it, the internal straight muscle.

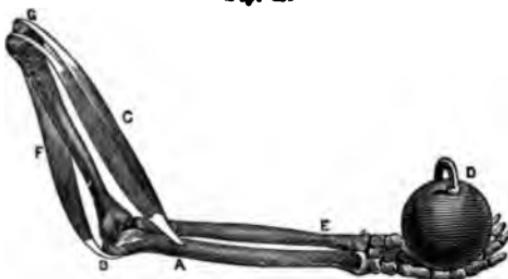
see an illustration of the *first class* of levers in the movements of the head. The back or front of the head is the weight to be lifted, the backbone is the fulcrum on which the lever turns, and the muscles at the back or front of

Fig. 18.



The three classes of Levers, and also the foot as a Lever.

FIG. 19.



The Hand as a Lever of 3d. class.

the neck are the powers by which we toss or bow the head.

When we raise the body on tiptoe, we have an instance of the *second class*. Here, our toes resting on the ground form the fulcrum, the muscle of the calf (*Gas-troc-né-mius, j.*, Fig. 14), acting through the tendon of the heel,* is the power, and the weight is borne by the ankle joint.

An illustration of the *third class* is found in lifting the hand from the elbow. The hand is the weight, the elbow the fulcrum, and the power is applied by the biceps muscle at its attachment to the radius. (A, Fig. 19.) In this form of the lever there is a great loss of force from its being applied at such a distance from the weight, but there is a gain of velocity, since the hand moves so far by such a slight contraction of the muscle. The hand is required to perform quick motions, and therefore this mode

* This is called the tendon of Achilles, and is so named because, as the fable runs, when Achilles was an infant his mother held him by the heel while she dipped him in the River Styx, whose water had the power of rendering one invulnerable to any weapon. His heel not being wet, was therefore his weak point, and here Paris, at last, directed the fatal arrow which killed the famous hero.—"This tendon will bear 1000 lbs. weight before it will break."—MAPOTHER.

The horse is said to be hamstrung, and so rendered useless, when the tendon of Achilles is cut.

of attachment is wisely adopted. The nearer the power is applied to the weight or resistance, the more easily the work is done. In the lower jaw, for example, the jaw is the weight, the fulcrum is the hinge-joint at the back, and the muscles (Mas'-se-ter, *e*, Fig. 14) on each side are the power.* They act much closer to the resistance than those in the hand, since here we desire force, and therefore speed.

The Enlargement of the Bones at the Joints not only affords greater surface for the attachment of the muscles, as we have seen, but also enables them to work to better advantage. Thus in Fig. 20 it is evident that a muscle acting in the line *fb* would not bend the lower limb so easily as if it were acting in the line *fh*, since in the former case its force would be about all spent in drawing the bones more closely together, while in the latter it would pull more nearly at a right angle. Thus the tendon *f*, by passing over the patella, which is itself pushed out by the protuberance *b* of the thigh-bone, pulls at a larger angle,† and so the leg is thrown forward with ease in walking and with great force in kicking.

How We Stand Erect.—The joints play so easily, and the centre of gravity in the body is so far above the

Fig. 20.



The Knee-joint:
h, the patella;
t, the tendon.

* We may feel the contraction of these muscles by placing our hand on the face while we work the jaw. The tendon of the muscle (Digastric) which opens the jaw passes through a pulley (*c*, Fig. 14) somewhat like the one in the eye.

† The chief use of the processes of the spine (see Fig. 6) and other bones is, in the same way, to throw out the point on which the power acts as far from the fulcrum as possible. The projection of the ulna ("funny-bone") behind the elbow, and that of the heel-bone to which the tendon of Achilles is attached, are excellent illustrations (Fig. 1).

Fig. 21.



*Action of the
Muscles which
keep the body
erect.*

foot, that the skeleton cannot of itself hold our bodies upright. Thus it requires the action of many muscles to maintain this position. The head so rests upon the spine as to tend to fall in front, but the muscles of the neck steady it in its place.* The hips incline forward, but are held erect by the strong muscles of the back. The trunk is nicely balanced on the head of the thigh-bones. The great muscles of the thigh acting over the knee-pan tend to bend the body forward, but the muscles of the calf neutralize this action. The ankle, the knee, and the hip lie in nearly the same line, and thus the weight of the body rests directly on the key-stone of the arch of the foot. So perfectly do these muscles act that we never think of them until science calls our attention to the subject, and yet to acquire the necessary skill to use them in our infancy needed patient lessons, much time, and many hard knocks.

How We Walk.—Walking is as complex an act as standing. It is really a perilous performance, which has become safe only because of constant practice. We see how violent it is when we run against a post in the dark,

* In animals, the jaws are so heavy, and the place where the head and spine join is so far back, that there can be no balance as there is in man. There are therefore large muscles in their necks. We readily find that we have none if we get on "all fours" and try to hold up the head. On the other hand, gorillas and apes cannot stand erect like man. Their head, trunk, legs, etc., are not balanced by muscles, so as to be in line with each other.

and find with what headlong force we were hurling ourselves forward. Holmes has well defined walking as a perpetual falling with a constant self-recovery. Standing on one foot we let the body fall forward, and swing the other leg ahead like a pendulum. Planting that foot on the ground to save the body from falling further, we then swing the first foot forward again to repeat the same operation.* The shorter the pendulum, the more rapidly it vibrates; and so short-legged people take quicker and shorter steps than long-legged ones.† We are shorter when walking than when standing still, because of this falling forward to take a step in advance.‡ We can carry the body ahead by purely muscular exertion, but it requires more effort.

In running, we incline the body more, and so, as it were, fall faster. When we walk, one foot is on the ground all the time, and there is an instant when both feet are planted upon it; but in running there is an interval of time in each step when both feet are off the ground, and the body is wholly unsupported. As we step alternately with the feet, we are inclined to turn the body first to one side and then to the other. This movement is sometimes counterbalanced by swinging the hand on the opposite side.

The Muscular Sense.—When we lift an object, we feel a sensation of weight, which we can compare with

* It is a curious fact that one side of the body tends to out-walk the other; and so when a man is lost in the woods he often goes in a circle and at last comes round to the spot whence he started.

† In this respect Commodore Nutt is to Magrath, whose skeleton, eight and one-half feet high, is now in the Dublin Museum, as a little, fast-ticking, French mantel-clock is to a big, old-fashioned, upright, corner time-piece.

‡ Women find that a dress which will swing clear of the ground when they are standing still, will drag the street when they are walking.

that experienced in lifting another body.* By care we may cultivate this sense so as to form a very precise estimate of the weight of a body by balancing it in the hand. The muscular sense is useful to us in many ways. It guides us in standing or moving. We gratify it when we walk erect and with an elastic step, and by dancing, jumping, skating, and gymnastic exercises.

Necessity of Exercise.—The effect of exercise upon a muscle is very marked.† By use it grows larger, and becomes hard, compact, and darker-colored; by disuse it decreases in size, and becomes soft, flabby, and pale.

Violent exercise, however, is injurious, since we then tear down faster than nature can build up. Feats of strength are not only hurtful, but dangerous. Often the muscles are strained or ruptured and blood-vessels burst in the effort to outdo one's companions.‡

Two thousand years ago Isocrates, the Greek rhetorician, said, "Exercise for health, not for strength." The cultivation of muscle for its own sake is a return to barbarism, while it enfeebles the mind, and ultimately the body. The ancient gymnasts are said to have become prematurely old, and the trained performers of our own

* If a small ivory ball be allowed to roll down the cheek toward the lips, it will appear to increase in weight. In general, the more sensitive parts of the body recognize smaller differences in weight, and the right hand is more accurate than the left. We are very apt, however, to judge of the weight of a body from previous conceptions. Thus, shortly after Sir Humphrey Davy discovered the metal Potassium, he placed a piece of it in Dr. Pierson's hand, who exclaimed, "Bless me! How heavy it is!" Really, however, potassium is so light that it will float on water like cork.

† The greater size of the breast (Pectoral muscle) of a pigeon, as compared with that of a duck, shows how muscle increases with use. The breast of a chicken is white because it is not used for flight, and therefore gets little blood.

‡ Instances have been known of children falling dead from having carried to excess so pleasant and healthful an amusement as jumping the rope, and of persons rupturing the tendon of Achilles in dancing.

day soon suffer from the strain they put upon their muscular system. Few men have vigor sufficient to become both athletes and scholars. Exercise should, therefore, merely supplement the deficiency of our daily employment. *A sedentary life needs daily, moderate exercise, which always stops short of fatigue.* This is a law of health.

No education is complete which fails to provide for the development of the muscles. Recesses should be as strictly devoted to play as study-hours are to work. Were gymnastics or calisthenics as regular an exercise as grammar or arithmetic, fewer pupils would be compelled to leave school on account of ill health; while spinal curvatures, weak backs, and ungraceful gaits would no longer characterize so many of our best institutions.

Time for Exercise.—We should not exercise after long abstinence from food, nor immediately after a meal, unless the meal or the exercise be very light. There is an old-fashioned prejudice in favor of exercise before breakfast—an hour suited to the strong and healthy, but entirely unfitted to the weak and delicate. On first rising in the morning, the pulse is low, the skin relaxed, and the system susceptible to cold. Feeble persons, therefore, need to be braced with food before they brave the out-door air.

What Kind of Exercise to Take.—For children, games are unequalled. Walking, the universal exercise,* is beneficial, as it takes one into the open air and sunlight. Running is better, since it employs more muscles, but must not be pushed to excess, as it taxes the heart, and

* The custom of walking, so prevalent in England, has doubtless much to do with the superior physique of its people. It is considered nothing for a woman to take a walk of eight or ten miles, and long pedestrian excursions are made to all parts of the country. The benefits which accrue from such an open-air life are sadly needed by the women of our own country. A walk of half-a-dozen miles should be a pleasant recreation for any healthy person.

may lead to disease of that organ. Rowing is more effectual in its general development of the system. Swimming employs the muscles of the whole body, and is a valuable acquirement, as it may be the means of saving life. Horseback riding is a fine accomplishment, and refreshes mind and body alike. Gymnastic or calisthenic exercises, when carefully selected, and not indulged immoderately, bring into play all the muscles of the body, and become preferable to any other mode of in-door exercise.

The Wonders of the Muscles.—The grace, ease, and rapidity with which the muscles contract are astonishing. By practice they acquire a facility which we call mechanical. The voice may utter 1500 letters in a minute, yet each requires a distinct position of the vocal organs. We train the muscles of the fingers till they glide over the keys of the piano, executing the most exquisite and difficult harmony. In writing, each letter is formed by its peculiar motions, yet we make them so unconsciously that a skillful penman will describe the most beautiful curves while thinking only of the idea which the sentence may express. The mind of the violinist is upon the music which his right hand is executing, while his left determines the length of the string and the character of each note so carefully that not a false sound is heard, although the variation of a hair's breadth would cause a discord. In the arm of a blacksmith the biceps muscle may grow into the solidity almost of a club; the hand of a prize-fighter will strike a blow like a sledge-hammer; while the engraver traces lines invisible by the naked eye, and the fingers of the blind acquire a delicacy that almost supplies the place of the missing sense.

Diseases, etc.—1. *St. Vitus's Dance* is a disease

of the voluntary muscles, whereby they are in frequent, irregular, and spasmodic motion beyond the control of the will. All causes of excitement, and especially of fear, should be avoided, and the general health of the patient invigorated. With renewed strength this disease will generally pass away.

2. *Convulsions* are an involuntary contraction of the muscles. Consciousness is wanting, while the limbs may be stiff or in spasmodic action. (See Appendix.)

3. *Locked-jaw* is a disease in which there are spasms and a contraction of the muscles, usually beginning in the lower jaw. It is serious, often fatal, yet it is sometimes caused by as trivial an injury as the stroke of a whip-lash, the lodgement of a bone in the throat, a fish-hook in the finger, or the puncture of the sole of the foot by a tack or nail.

4. *Gout* is an acute pain located chiefly in the small joints of the foot, especially those of the great toe, which become swollen and extremely sensitive. It is generally brought on by high living.

5. *Rheumatism* affects mainly the fibrous tissue of the larger joints. While gout is the punishment of the rich who live luxuriously and indolently, rheumatism more frequently afflicts the poor and those who toil. There are two common forms of rheumatism—the inflammatory or acute, and the chronic. The latter is of long continuance; the former terminates more speedily. The acute form is probably a disease of the blood, which carries with it some poisonous matter which is deposited where the fibrous tissue is most abundant. The disease flies from one joint to another in the most unaccountable manner, and the pain caused by even the slightest motion deprives the sufferer

of the use of the disabled part and its muscles. The chief danger to be feared is the possibility of its going to the heart. The utmost precaution should therefore be used to prevent such a result. Physicians do not agree upon any specific mode of treating this disease. Warm fomentations are usually grateful. Chronic rheumatism—the result of repeated attacks of the acute—leads to great suffering, and oftentimes to disorganization of the joints, and an interference with the movements of the heart.

6. *Lumbago* is a disease of the muscles of the back.* It may be so moderate as to produce only a "lame back," or so severe as to disable, as in the case of a "crick in the back." Strong swimmers who sometimes suddenly drown without apparent cause are supposed to be seized in this way.

7. *A Ganglion*, or what is vulgarly called a "weak" or "weeping" sinew, is a swelling of a bursa.† It sometimes becomes so distended by fluid as to be mistaken for bone. If on binding something hard upon it for a few days it does not disappear, a physician will easily remove it.

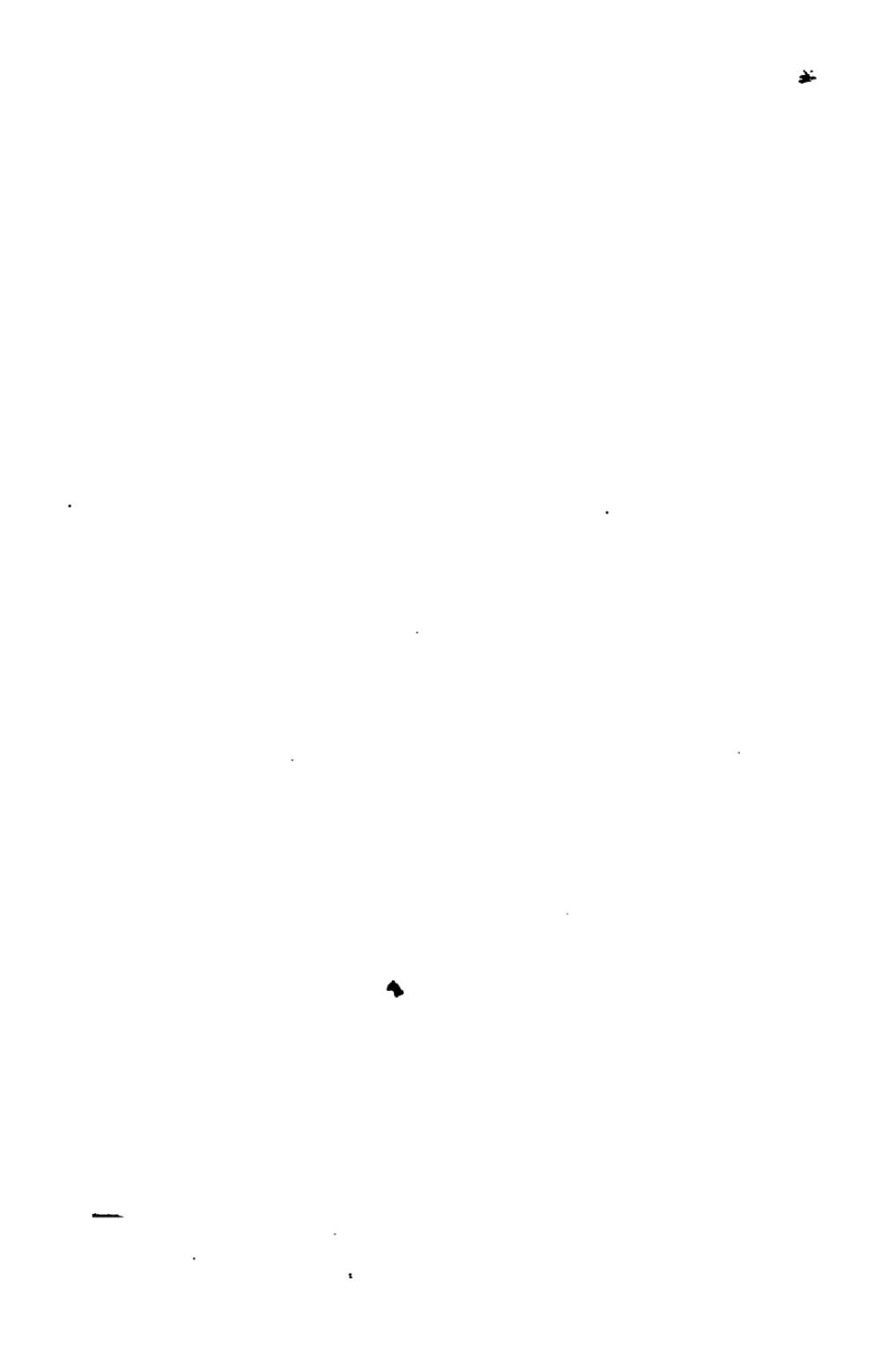
PRACTICAL QUESTIONS.

1. What class of lever is the foot when we lift a weight on the toes?

* Lumbago is really a form of myalgia, a disease which has its seat in the muscles, and may thus affect any part of the body. Doubtless much of what is commonly called "liver" or "kidney complaint" is only, in one case, myalgia of the chest or abdominal walls near the liver, or, in the other, of the back and loins near the kidneys. Chronic liver disease is comparatively rare in the northern States, and pain in the side is not a prominent symptom, while certain diseases of the kidneys, which are as surely fatal as pulmonary consumption, are not attended by pain in the back opposite these organs.—*W.E.Y.*

† A bursa is a small sack containing a lubricating fluid to prevent friction where tendons play over hard surfaces. There is one shaped like an hour-glass on the wrist, just at the edge of the palm. By pressing back the liquid it *contains, this bursa may be clearly seen.*

3. Explain the movement of the body backward and forward, when resting upon the thigh-bone as a fulcrum.
3. What class of lever do we use when we lift the foot while sitting down ?
4. Explain the swing of the arm from the shoulder.
5. What class of lever is used in bending our fingers ?
6. What class of lever is our foot when we tap the ground with our toes ?
7. What class of lever do we use when we raise ourselves from a stooping position ?
8. What class of lever is the foot when we walk ?
9. Why can we raise a heavier weight with our hand when lifting from the elbow than from the shoulder ?
10. What class of lever do we employ when we are hopping, the thigh-bone being bent up toward the body and not used ?
11. Describe the motions of the bones when we are using a gimlet.
12. Why do we tire when we stand erect ?
13. Why does it rest us to change our work ?
14. Why and when is dancing a beneficial exercise ?
15. Why can we exert greater force with the back teeth than with the front ones ?
16. Why do we lean forward when we wish to rise from a chair ?
17. Why does the projection of the heel-bone make walking easier ?
18. Does a horse travel with less fatigue over a flat than a hilly country ?
19. Can you move your upper jaw ?
20. Are people naturally right or left-handed ?
21. Why can so few persons move their ears by the muscles ?
22. Is the blacksmith's right arm healthier than the left ?
23. Boys often, though foolishly, thrust a pin into the flesh just above the knee. Why is it not painful ?
24. Will ten-minutes practice in a gymnasium answer for a day's exercise ?
25. Why would an elastic tendon be unfitted to transmit the motion of a muscle ?
26. When one is struck violently on the head, why does he instantly fall ?
27. What is the cause of the difference between light and dark meat in a fowl ?



III.

THE SKIN.

— A protection from the outer world, it is our only means of communicating with it. Insensible itself, it is the organ of touch. It feels the pressure of a hair, yet bears the weight of the body. It yields to every motion of that which it wraps and holds in place. It hides from view the delicate organs within, yet the faintest tint of a thought shines through, while the soul paints upon it, as on a canvas, the richest and rarest of colors.



THE SKIN.

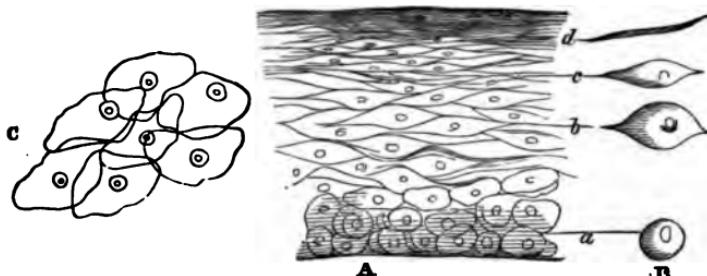
THE Skin is a tough, thin, close-fitting garment for the protection of the tender flesh. Its perfect elasticity beautifully adapts it to every motion of the body. We shall learn hereafter that it is more than a mere covering, being an active organ, which does its part in the work of keeping in order the house in which we live. It oils itself to preserve its smoothness and delicacy, replaces itself as fast as it wears out, and is at once the perfection of use and beauty.

Structure.—What we commonly call the skin—viz., the part raised by a blister—is only the cuticle* or covering of the cutis or true skin. The latter is full of nerves and blood-vessels, while the former neither bleeds † nor gives rise to pain, neither suffers with heat nor feels the cold. The cuticle is composed of small flat cells or scales. These are constantly being shed from the surface in the form of

* *Cuticula*, little skin. It is often styled the scarf-skin, and also the epidermis (epi, upon; and *derma*, skin).

† We notice this in shaving; for if a razor goes below the cuticle it is followed by pain and blood. So insensible is this outer layer that we can run a pin through the thick mass at the roots of the nails without discomfort.

Fig. 22.



A represents a vertical section of the cuticle. B, lateral view of the cells. C, flat side of scales like d, magnified 250 diameters.

scarf, dandruff, etc., but are as constantly renewed from the cutis,* below.

Under the microscope we can see the round cells of the skin, and how they become flattened and hardened as they are forced to the surface. The immense number of these cells surpasses comprehension. In one square inch of the cuticle, counting only those in a single layer, there are more than a billion of horny scales, each complete in itself.

—HARTING.

Value of the Cuticle.—In the palm of the hand, the sole of the foot, and other parts especially liable to injury, the cuticle is very thick. This is a most admirable provision for their protection.† By use it becomes callous and horny. The boy who goes out barefoot for the first time, “treading as if on eggs,” can soon run where he pleases

* We see how rapidly this change goes on by noticing how soon a stain of any kind disappears from the skin. A snake throws off its cuticle entire, and at regular intervals.

† We can hold the hand in strong brine with impunity, but the smart will quickly tell us when there is even a scratch in the skin. In vaccination the matter must be inserted beneath the cuticle to take effect. Doubtless this membrane prevents many poisonous substances from entering the system.

among thistles and over stones. The blacksmith handles hot iron without pain, while the mason lays stones and works in lime without scratching or corroding his flesh.

The Complexion.—In the freshly-made cells on the lower side of the cuticle, is a pigment composed of tiny grains.* In the varying tint of this coloring-matter lies the difference of hue between the blonde and the brunette, the European and the African. In the purest complexion there is some of this pigment, which, however, disappears as the fresh, round, soft cells next to the cutis change into the old, flat, horny scales at the surface. Scars are white, because this part of the cuticle is not restored. The sun has a powerful effect upon the coloring matter, and so we readily “tan” on exposure to its rays. If the color gathers in spots, it forms freckles.†



HAIR AND NAILS.

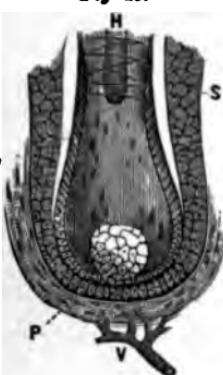
The Hair and the Nails are modified forms of the cuticle.

The Hair is a protection from heat and cold, and

* These grains are about $\frac{1}{1000}$ of an inch in diameter, and curiously enough do not appear opaque but transparent and nearly colorless.—MARSHALL.

† This action of the sun on the pigment of the skin is very marked. Even among the Africans the skin is observed to lose its intense black color in those who live for many months in the shades of the forest. It is said that Asiatic and African women confined within the walls of the harem, and thus secluded from the sun, are as fair as Europeans. Among the Jews who have settled in Northern Europe are many of light complexion, while those who live in India are as dark as the Hindoos. The black pigment has been known to disappear during severe illness and a lighter color to be developed in its place. Among the negroes are sometimes found people who have no complexion, i. e., there is no coloring matter in their skin, hair, or the iris of their eyes. These persons are called Albinoa.

Fig. 23.



A hair magnified 600 diameters. S, the sac (follicle); P, the papilla, showing the cells and the blood-vessels (V).

shields the head from blows. It is found on nearly all parts of the body, except the palms of the hands and the soles of the feet. The outside of a hair is hard and compact, and consists of a layer of colorless scales, which overlie one another like the shingles of a house; the interior is porous,* and probably conveys the liquids by which it is nourished. Each hair grows from a tiny bulb (papilla), which is an elevation of the cutis at the bottom of a little hollow in the skin. From the surface of

this bulb the hair is produced, like the cuticle, by the constant formation of new cells at the bottom. When the hair is pulled out, this bulb, if uninjured, will produce a new one; but when once destroyed, it will never grow again. The hair has been known to whiten in a single night by fear, fright, or nervous excitement. When the color has once changed it cannot be restored.†

* In order to examine a hair, it should be put on the slide of the microscope, and covered with a thin glass while a few drops of alcohol are allowed to flow between the cover and the slide. This causes the air, which fills the hair and prevents our seeing its structure, to escape.

† Hair dyes or so-called "hair restorers" are almost invariably deleterious substances, depending for their coloring properties upon the action of lead or lunar caustic. Frequent instances of hair poisoning have of late occurred, owing to the common use of such dangerous articles. If the growth of the hair be impaired, the general constitution or the skin needs treatment. This is the work of a skillful physician, and not of a patent remedy. Dame Fashion has her repentant freaks as well as her ruinous follies, and it is a healthful sign that the era of universal hair-dyeing has been blotted out from her present calendar, and the gray hairs of age are now honored with the highest place in "style" as well as in good-sense and cleanliness.

The hair is said to grow after death. This is due to the fact that by the shrinking of the skin the part below the surface is caused to project, which is especially noticeable in the beard.

Wherever hair exists tiny muscles are found, interlaced among the fibres of the skin. These, when contracting under the influence of cold or electricity, pucker up the skin and cause the hair to stand on end.* The hairs themselves are destitute of feeling. Nerves, however, are found in the hollows in which the hair is rooted, and so one feels pain when it is pulled.† Thus the insensible hairs become most wonderfully delicate instruments to convey an impression of even the slightest touch.

Next to the teeth and bones, the hair is the most indestructible part of the body, and its color is often preserved for many years after other portions have gone to decay.‡

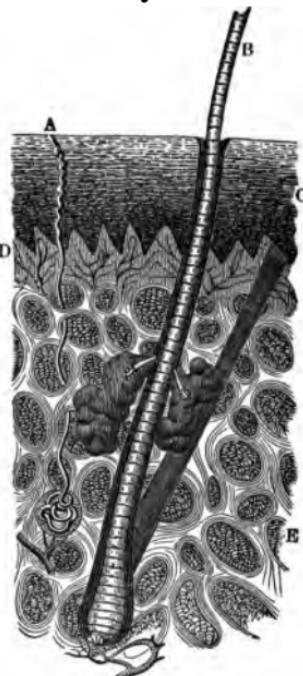
The Nails protect the ends of the tender finger and toe, and give us power more firmly to grasp and easily to pick up any object we may desire. They enable us to perform a hundred little, mechanical acts which else were impossible.

* In horses and other animals which are able to shake the whole skin to drive away the flies, this muscular tissue is much more fully developed than in man.

† These nerves are especially abundant in the whiskers of the cat, which are used as feelers.

‡ Fine downy hairs so general upon the body have been detected in some fragments of skin found beneath the heads of the nails by which, centuries ago, certain robbers were affixed to the church doors, as a punishment for their sacrilege.

FIG. 24.



A, a perspiratory tube with its gland; B, a hair with a muscle and two oil-glands; C, cuticle; D, the papillæ; and E, fat-cells.

At the same time their delicate color and beautiful outline give a finish of ornament to that most exquisite instrument, the hand. The nail is firmly set in a groove (matrix) in the cuticle, from which it grows at the root in length* and from beneath in thickness. As long as the matrix at the root is uninjured, the nail will be replaced after any accident.

THE MUCOUS MEMBRANE.

Structure.—At the edges of the openings into the body, the skin seems to stop and give place to a tissue which is redder, more sensitive, more liable to bleed, and is moistened by a fluid, or mucus as it is called. Really, however, the skin does not cease, but passes into a more delicate covering of the same general composition, viz., an outer hard, bloodless, insensible layer, and an inner soft, sanguine, nervous one.† Thus every part of the body is contained in a kind of double bag, made of the tough skin on the outside, and the tender mucous membrane on the inside.

Connective Tissue.—The cutis and the corresponding layer of the mucous membrane consist of a fibrous substance interlaced like felt. It is called connective tis-

* By making a little mark on the nail near the root, we can see week by week how rapidly this process goes on, and so form some idea of what a multitude of cells must be transformed into the horny matter of the nail.

† With a dull knife we can scrape from the mucous membrane which lines the mouth some of the cuticle for examination under the microscope. In a similar way we can obtain cuticle from the surface of the body for study and comparison.

sue, because it connects all the different parts of the body. It spreads from the cutis, invests muscles, bones, and cartilages, and thence passes into the mucous membrane. So thoroughly does it permeate the body, that if the other tissues were destroyed, it would still give a perfect model of every organ. It can be seen in a piece of meat as a delicate substance lying between the layers of muscle, where it serves to bind together the numerous fibres of which they are composed.* Connective tissue yields gelatine on boiling, and is the part which tans when hides are manufactured into leather. It is very elastic, so that when you remove your finger after pressing upon the skin, no indentation is left.† It varies greatly in character—from the mucous membrane, where it is soft and tender, to the ligaments and tendons, which it largely composes, where it is strong and dense.‡

Fat is deposited as an oil in the cells§ of this tissue, just beneath the skin (Fig. 24), giving roundness and plumpness to the body, and acting as a powerful non-conductor for the retention of heat.|| It collects as pads in the hollows of the bones, around the joints, and between the muscles, causing them to glide more easily upon each other. As marrow, it nourishes the skeleton, and also distributes the shock of any jar the limb may sustain. It is

* Sometimes butchers blow air into veal, which fills the tiny cells of this tissue, and causes the meat to appear plump.

† In dropsy this elasticity is lost by distension, and there is a kind of "pitting," as it is called, produced by pressure.

‡ The leather made from this tissue varies as greatly, from the tough, thick ox-hide to the soft, pliable kid and chamois skin.

§ So tiny are these cells, that there are over 65,000,000 in a cubic inch of fat.—**VALENTINE.**

|| As the cells of the tissue are kept moistened, the liquid does not ooze out, but, on drying, it comes to the surface. For this reason a piece of fat feels oily when exposed to the air.

noticeable, however, that fat does not gather within the cranium, the lungs, or the eye-lids, where its accumulation would clog the organs.

THE TEETH.

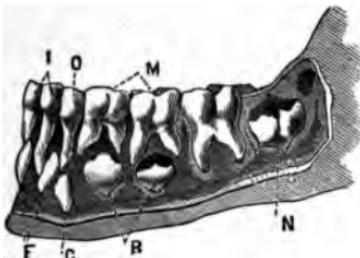
The Teeth * are thirty-two in all—there being eight in each half jaw, similarly shaped and arranged. In each set of eight, the two nearest the middle of the jaw have wide, sharp, chisel-like edges, fit for cutting, and hence are called *incisors*. The next corresponds to the great tearing or holding tooth of the dog, and is styled the *canine*, or eye-tooth. The next two have broader crowns, with two points or cusps, and are hence termed the *bicuspid*s. The remaining three are much broader, and as they are used to crush the food, are called the *grinders* or *molars*. The incisors and eye-teeth have one fang or root, the others have two or three each.

The Milk-teeth.—We are provided with two sets of teeth. The first, or milk-teeth, are small and only twenty in number. In each set of five there are two incisors, one canine, and two molars. The middle incisors are usually cut about the age of seven months, the others at nine months, the first molars at twelve months, the canines at

* Although the teeth are always found in connection with the skeleton, and are, therefore, figured as a part of it (Fig. 1), yet they do not properly belong to the bones of the body, and are merely set in the solid jaw to insure solidity. They are hard, and resemble bony matter, yet they are neither true bone nor are they formed in the same manner. "They are properly appendages of the mucous membrane, and are developed from it."—LEIDY. "They belong to the Tegumentary System, which, speaking generally of animals, includes teeth, nails, horns, scales, and hairs."—MARSHALL. They are therefore classed with the mucous membrane, as are the nails and hair with the skin.

eighteen months, and the remaining molars at two or three years of age. The lower teeth precede the corresponding upper ones. The time often varies, but the order seldom.

Fig. 25.



The Teeth at the age of six and one-half years. I, the incisors; O, the canine; M, the molars; the last molar is the first of the permanent teeth; F, sacs of the permanent incisors; C, of the canine; B, of the bicuspids; N, of the 2d. molar; the sac of the 3d. molar is empty.—MARSHALL.

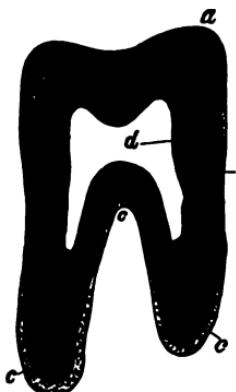
The Permanent Teeth.—At six years, when the first set are usually still perfect, the jaws contain the crowns of all the second, except the wisdom-teeth. About this age, to meet the wants of the growing body, the crowns of the permanent set begin to press against the roots of the milk-teeth, which, becoming absorbed, leave the loosened teeth to drop out, while the new ones rise and occupy their places.* The central incisors appear at about seven years of age, the others at eight; the first bicuspids at nine, the second at ten; the canines at eleven or twelve; the second† molars at twelve or thirteen, and the last, or wisdom-teeth, are sometimes delayed until the twenty-second year, or even later.

* If the milk-teeth do not promptly loosen on the appearance of the second set, the former should be at once removed to permit the permanent set to assume their natural places. If any fail to come in regularly, or if they crowd the others, a competent dentist should at once be consulted.

† The first molar appears much earlier. (See Fig. 26.)

Structure of the Teeth.—The interior of the tooth consists principally of *dentine*, a dense substance resembling bone.* The crown of the tooth, which is exposed to wear, is protected by a sheath of *enamel*. This is a hard, glistening, white substance, containing only two and a half per cent. of animal matter. The fang is covered by a thin layer of true bone (cement). At the centre of the tooth is a cavity filled with a soft, reddish-white, pulpy substance full of blood-vessels and nerves. This pulp is very sensitive, and toothache is caused by its irritation.

Fig. 27.



Vertical section of a Molar Tooth, moderately magnified. a, enamel of the crown, the lines of which indicate the arrangement of its columns; b, dentine; c, cement; d, pulp cavity.

The Fitting of the Tooth into the Jaw is a most admirable contrivance. It is not set, like a nail in wood, having the fang in contact with the bone; but the socket is lined with a membrane which forms a soft cushion. While this is in a healthy state, it deadens the force of any shock, but when inflamed, becomes the seat of excruciating pain.

The Decay of the Teeth† is commonly caused (1) by portions of the food which become entangled be-

* In the tusk of the elephant this is known as ivory.

† Unlike the other portions of the body, there is no provision made for any change in the permanent teeth. That part, however, which is thus during life most liable to change, after death resists it the longest. In deep-sea dredgings they are found when all traces of the frame to which they belonged have disappeared. Yet hard and incorruptible as they seem, their permanence is only relative. Exposed to injury and disease, they break or decay. Even if they escape accident, they yet wear at the crown, are absorbed at the fang, and, in time, drop out, thus affording another of the many signs of the limitations Providence has fixed to the endurance of our bodies and the length of our lives.

tween them, and on account of the heat and moisture, quickly decompose. Also (2), as the saliva evaporates, it leaves on the teeth a sediment, which we call *tartar*. This collects the organic matter, which rapidly changes, and also affords a soil in which a sort of fungus speedily springs up. From both these causes the breath becomes offensive, and the teeth are injured.

Preservation of the Teeth.—Children should early be taught to brush their teeth at least every morning with tepid water, and twice a week with soap and powdered orris-root. They should also be instructed to remove the particles of food from between the teeth, after each meal, by means of a quill or wooden tooth-pick. The enamel once injured is never restored, and the whole interior of the tooth is exposed to decay. We should not, therefore, crack hard nuts, bite thread, use metal tooth-picks, gritty tooth-powders, or any acid that “sets the teeth on edge,” i. e., that acts upon the enamel. It is well also to have the teeth examined yearly by a dentist, that any small orifice may be filled, and further decay prevented.

GLANDS OF THE SKIN.

I **The Oil Glands** are clusters of tiny sacs which secrete an oil that flows along the duct to the root of the hair, and thence oozes out on the cuticle.* (See Fig. 24.) This is nature’s efficient hair-dressing, and also keeps the

* This secretion is said to vary in different persons, and on that account the dog is enabled to track his master by the scent.

skin soft and flexible. These glands are not found where there is no hair, as on the palm of the hand, and hence at those points only can water readily soak through the skin into the body. They are of considerable size on the face, especially about the nose. When obstructed, their contents become hard and dark-colored, and are vulgarly called "worms."*

II. The Perspiratory Glands are fine tubes about $\frac{1}{16}$ of an inch in diameter, and a quarter of an inch in length, which run through the cutis, and then coil up in little balls. (Fig. 24.) They are found in all parts of the body, and in almost incredible numbers. In the palm of the hand there are about 2,800 in a single square inch. On the back of the neck and trunk, where they are fewest, there are yet 400 to the square inch. The total number on the body of an adult is estimated at about two and a half million. If they were laid end to end, they would extend nearly ten miles.† The mouths of these glands—"pores," as we commonly call them—may be seen with a pocket lens along the fine ridges which cover the palm of the hand.

The Perspiration.—From these openings there constantly passes a vapor, forming what we call the insensible perspiration. Exercise or heat causes it to flow more freely, when it condenses on the surface in drops. The perspiration consists of about ninety-nine parts water and

* Though they are not alive, yet, under the microscope, they are sometimes found to contain a curious parasite called the pimple-mite, which is supposed to consume the superabundant secretion.

† The current statement, that they would extend twenty-eight miles, is undoubtedly an exaggeration. Krause estimates the total number at 2,881,248, and the length of each coil, when unravelled, at $\frac{1}{16}$ of an inch, which would make the total length much less than even the statement in the text.

one part solid matter. The amount varies greatly, but on the average is, for an adult, not far from two pounds per day. The importance of this constant drainage has been shown by frequent experiments. Small animals, as the rabbit, when coated with varnish so as to close the pores, die within twelve hours.*

The Absorbing Power of the Skin.—We have already described two uses of the skin: (1) Its *protective*, (2) its *exhaling*, and now we come (3) to its *absorbing* power. This is not so noticeable as the others, and yet it can be easily proved. Persons frequently poison their hands with the common wood-ivy. Contagious diseases are caught by touching a patient, or even his clothing.† Painters absorb so much lead through the pores of their hands that they are attacked with colic.† Snuff and lard are frequently rubbed on the chest of a child suffering with the croup to produce vomiting. Seamen in want of water drench their clothing in salt spray, and the skin will absorb enough to quench thirst. (See *Lymphatic System*, p. 123.)

By carefully conducted experiments it has been found

* Once, on an occasion of great solemnity at Rome, a child was, it is said, completely covered with gold leaf, closely applied to the skin, so as to represent, according to the idea of that age, the golden glory of an angel or seraph. In a few hours after contributing to this pageant, the child died; the cause being suffocation, from stopping the exhalation of the skin; although, in the ignorance of the common people of those days, the death was attributed to the anger of the Deity, and looked upon as a circumstance of evil omen.

† If one is called upon to handle a dead body, it is well, especially if the person has died of a contagious disease, to rub the hand with lard or olive-oil. Poisonous matter has been fatally absorbed through the breaking of the cuticle by a hang-nail or a simple scratch. There is a story that Napoleon I., when a lieutenant of artillery, in the heat of battle, seized the rammer and worked the gun of an artillery-man who had fallen. From the wood which the soldier had handled, Napoleon absorbed a poison which gave him a skin-disease, by which he was annoyed the remainder of his life.

‡ Cosmetics, powders, hair-dyes, etc., are exceedingly injurious, not only because they tend to fill the pores of the skin, but because they often contain poisonous matters which are absorbed into the system.

that the skin acts in the same way as the lungs (see *Respiration*, p. 92) in absorbing oxygen from the air, and giving off carbonic acid to an appreciable amount. Indeed, the skin has not inaptly been styled the third lung.*

Hints about Washing and Bathing.—The moment of rising from bed is the proper time for the full wash or bath with which one should commence the day. The body is then warm, and can endure moderately cool water better than at any other time; it is relaxed, and needs bracing, and the nerves, deadened by the night's repose, require a gentle stimulus. If the system be strong enough to resist the shock, cold water is the most invigorating; if not, a tepid bath will answer.† Before dressing, the whole body should be thoroughly rubbed with a coarse towel or flesh-brush. At first the friction may be unpleasant, but this sensitiveness will soon be overcome, and the keenest pleasure be felt in the lively glow which follows. A bath should not be taken just before nor immediately after a meal, as it will interfere with the diges-

* In some of the lower animals it plays a still more important part. Frogs, deprived of their lungs, breathe with almost undiminished activity, and often survive for days. Snakes get their main supply of air through the skin.

† Many persons have not the conveniences for a bath. To them the following plan, which the author has daily employed for years, is commended. The necessities are: a basin full of soft water, a mild soap, a large sponge or a piece of flannel, and two towels—one soft, the other rough. The temperature of the water should vary with the season of the year—cold in summer, and tepid in winter. Rub quickly the entire body with the wet sponge or flannel. (If more agreeable, wash and wipe only a part at a time, protecting the rest in cold weather with portions of the clothing.) Dry the skin gently with the soft towel, and, when quite dry, with the rough towel or flesh-brush rub the body briskly for four or five minutes till the skin is all aglow. The chest and abdomen need the principal rubbing. The roughness of the towel should be accommodated to the condition of the skin. Enough friction, however, must be given to produce at least a gentle warmth, indicative of the reaction necessary to prevent subsequent chill or languor. An invalid will find it exceedingly beneficial if a stout, vigorous person produce the reaction by rubbing with the hands.

tion of the food. Soap should be employed occasionally, but its frequent use tends to make the skin dry and hard.

Reaction.—After taking a cold bath there should be a prompt reaction. When the surface is chilled by cold water, the blood sets to the heart and other vital organs, exciting them to more vigorous action, and then being thrown back to the surface, it reddens, warms, and stimulates the skin to an unwonted degree. This is called reaction, and in it lies the invigorating influence of the cold bath. If, on the contrary, the skin be heated by a hot bath, the blood is drawn to the surface, less blood goes to the heart, the circulation decreases, and languor ensues. A dash of cool water is both necessary and refreshing at its close.* If, after a cold bath, there be felt no glow of warmth, but only a chilliness and depression, we are thereby warned that either proper means were not taken to bring on this reaction, or that the circulation is not vigorous enough to make such a bath beneficial. The general effect of a cool bath is exhilarating, and that of a warm one depressing.† Hence the latter should not ordinarily be taken oftener than once a week, while the former may be enjoyed daily.

* The Russians are very fond of vapor baths, taken in the following manner. A large room is heated by stoves. Red-hot stones being brought in, water is thrown upon them, filling the room with steam. The bathers sit on benches until they perspire profusely, when they are rubbed with soapsuds and dashed with cold water. Sometimes, while in this state of excessive perspiration, they run out of doors and leap into snow-banks.

† The sudden plunge into a cold bath is good for the strong and healthy, but too severe for the delicate. One should always wet first the face, neck, and chest. It is extremely injurious to stand in a bath with only the feet and lower limbs covered by the water, for the blood is thus sent from the extremities to the heart and internal organs, and they become so burdened that reaction may be out of their power. A brisk walk, or a thorough rubbing of the skin before a cold bath or swim, adds greatly to its value and pleasure.

2. *Dropsey* is a disease in which there is an accumulation of water in the system. On account of the free passage between the cells of the connective tissue, this liquid gradually settles into the feet when the person is standing; on reclining, the equilibrium is restored.

3. *Corns* are a thickened part of the cuticle, caused by pressure or friction. They most frequently occur on the feet; but are produced on the shoemaker's knee by constant hammering, and on the soldier's shoulder by the rubbing of his musket. This hard portion irritates the sensitive cutis beneath, and so causes pain. By soaking the feet in hot water, the corn will be softened, when it may be pared with a sharp knife. If the cause be removed, the corn will not return.

4. *In-growing Nails* are caused by pressure, which forces the edge of the toe-nail into the flesh. They may be cured by carefully cutting away the part which has mal-grown, and then scraping the back of the nail till it is thin and no longer resists the pressure. The two portions, uniting, will draw away the nail from the flesh at the edge. They are prevented by paring the nail straight across, thus making the corners right angles, and by wearing broad shoes.

5. *Warts* are overgrown papillæ. (Fig. 24.) They may generally be removed by the application of glacial acetic acid, or a drop of nitric acid, repeated until the entire structure is softened. Care must be taken to keep the acid from touching the neighboring skin. The capricious character of warts has given rise to the popular delusion concerning the influence of charms upon them.

6. *Chilblain* is a local inflammation affecting generally the feet, hands, or lobes of the ear. Liability to it gen-

erally passes away with manhood. It is not caused by "freezing the feet," as many suppose, though attacks are brought on or aggravated by exposure to cold and by sudden warming. It is subject to daily congestion (see *Congestion*, page 125), manifested by itching, soreness, etc., commonly occurring at night. The best preventive is a uniform temperature and careful protection against the cold by warm, loose, and plentiful clothing, especially for the feet.

7. *Wens* are caused by an unnatural activity of the arteries, which deposit more nutriment than is needed. Physicians "scatter them," as it is termed, by stimulating the absorbents to carry off the excess. A boil often disappears without "coming to a head" in a somewhat similar way, i. e., by the renewed activity of the absorbing vessels.

PRACTICAL QUESTIONS.

1. If a hair be plucked out, will it grow again?
2. What causes the hair to "stand on end" when we are frightened?
3. Why is the skin roughened by riding in the cold?
4. Why is the back of a washer-woman's hand less water-soaked than the palm?
5. What would be the length of the perspiratory tubes in a single square inch of the palm, if placed end to end?
6. What colored clothing is best adapted to all seasons?
7. What is the effect of paint and powder on the skin?
8. Is water-proof clothing healthful for constant wear?
9. Why are rubbers cold to the feet?
10. Why does the heat seem oppressive when the air is moist?
11. Why is friction of the skin invigorating after a cold bath?
12. Why does the hair of domestic animals become roughened in winter?

13. Why do fowls shake out their feathers erect before they perch for the night?
14. How can an extensive burn cause death by congestion of the lungs?
15. Why do we perspire so profusely after drinking cold water?
16. What are the best means of preventing skin diseases, colds, and rheumatism?
17. What causes the difference between the hard hand of a blacksmith and the soft hand of a woman?
18. Why should a painter avoid getting paint on the palm of his hand?
19. Why should we not use the soap or soiled towel at a hotel?
20. Which teeth cut like a pair of scissors?
21. Which like a chisel?
22. Which should be clothed the warmer, a merchant or a farmer?
23. Why should we not crack nuts with our teeth?
24. Do the edges of the upper and lower teeth meet?
25. When fatigued, would you take a cold bath?
26. Why is the outer surface of a kid glove finer than the inner?
27. Why will a brunette endure the sun's rays better than a blonde?
28. Does patent-leather form a healthy covering for the feet?
29. Why are men more frequently bald than women?
30. On what part of the head does baldness commonly occur? Why?
31. What does the combination in our teeth of canines and grinders suggest as to the character of our food?
32. Is a staid, formal promenade suitable exercise?
33. Is there any danger in changing the warm clothing of our daily wear for the thin one of a party?
34. Should we retain our overcoat, shawl, or furs when we come into a warm room?
35. Which should bathe the oftener, students or out-door laborers?
36. Is abundant perspiration injurious?

IV.

RESPIRATION
AND
THE VOICE.



‘THE smooth soft air with pulse-like waves
Flows murmuring through its hidden caves,
Whose streams of brightening purple rush,
Fired with a new and livelier blush;
While all their burthen of decay
The ebbing current steals away.’



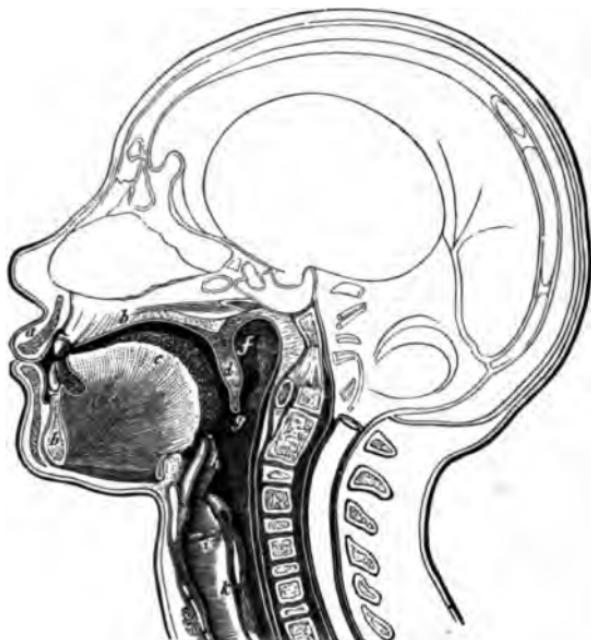
RESPIRATION AND THE VOICE.

THE organs of Respiration and the Voice are the *larynx*, the *trachea*, and the *lungs*.

Description of the Organs of Voice.—*The Larynx*.—In the neck is a prominence sometimes called Adam's apple. It is the front of the *larynx*. This is a small triangular box, placed just behind the tongue, and at the top of the windpipe. The opening into it from the throat is called the *glottis*, and the cover the *epiglottis* (*epi*, upon; *glotta*, the tongue). The latter is a spoon-shaped lid, which opens when we breathe, but, by a nice arrangement, shuts when we try to swallow, and so lets our food slip over it into the *œsophagus* (e-sof'-a-gus), the tube leading to the stomach. (See Fig. 27.) If we laugh or talk when we swallow, our food is apt to “go the wrong way,” *i. e.*, little particles pass into the larynx, and the tickling sensation which they produce forces us to cough, in order to expel the intruders.

The Vocal Cords.—On each side of the *glottis* are the so-called *vocal cords*. They are not really cords, but

Fig. 27.



Passage to the Oesophagus and Windpipe: c, the tongue; d, the soft palate, ending in g, the uvula; h, the epiglottis; i, the glottis; l, the oesophagus; f, the pharynx.

merely elastic membranes projecting from the sides of the box across the opening.* When not in use, they spread apart and leave a V-shaped orifice (see Fig. 28), through which the air passes to and from the lungs. If the cords are tightened, the edges approach sometimes within $\frac{1}{100}$ of an inch of each other, and, being thrown into vibration, cause corresponding vibrations in the current of air. Thus sound is produced in the same manner as by the

* The cartilages and vocal cords of the larynx may be seen readily in that of the ox or sheep. If the flesh be cut off, the cartilages will dry and will keep for years.

vibrations of the tongues of an accordion, or the strings of a violin, only in this case the strings are scarcely an inch long.

Different Tones of the Voice.

—The higher tones of the voice are produced when the cords are short, tight, and closely in contact; the lower, by the opposite conditions. Loudness is regulated by the quantity of air and force of expulsion. A falsetto voice is thought to be the result of some change in the pharynx (Fig. 27) at the back part of the nose. When boys are about fourteen years of age, the larynx enlarges, and the cords grow proportionately longer and coarser; hence, the voice becomes deeper, or, as we say, "changes."

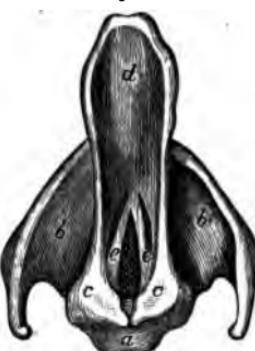
Speech is voice modulated by the lips, tongue,* palate, and teeth.† It is commonly associated with the voice, but is not necessary to it; for when we whisper we articulate the words, although there is no vocalization, i. e., no action of the larynx.‡

* The tongue is styled the "unruly member," and held responsible for all the tattling of the world; but when the tongue is removed, the adjacent organs in some way largely supply the deficiency, so that speech is still possible. Huxley described the conversation of a man who had two and one-half inches of his tongue preserved in spirits, and yet could converse intelligibly. Only the two letters *t* and *d* were beyond his power; hence, tin became "fin," and dog became "thog."

† An artificial larynx may be made by using elastic bands to represent the vocal cords, and by placing above them chambers which by their resonance will produce the same effect as the cavities lying above the larynx. An artificial speaking-machine was constructed by Kempelen, which could pronounce such sentences as, "I love you with all my heart," in different languages, by simply touching the proper keys.

‡ We can observe this by placing the hand on the throat, and noticing the absence of vibrations when we whisper, and their presence when we talk. The

Fig. 28.

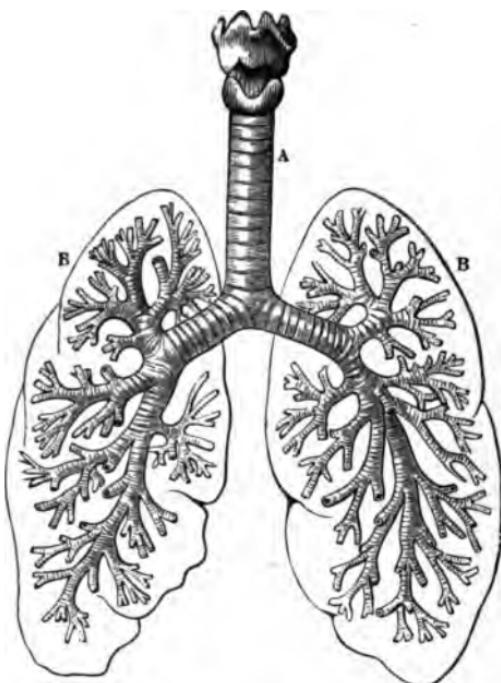


e, e, the vocal cords; d, the epiglottis.

Formation of Vocal Sounds.—The method of modulating voice into speech may be seen by producing the pure vowel sounds *a*, *e*, etc., from one expiration, the mouth being kept open while the form of the aperture is changed for each vowel by the tongue and the lips. *H* is only an explosion, or forcible throwing of a vowel sound from the mouth.

The consonants, or short sounds, may also be made

Fig. 29.



The Lungs, showing the Larynx. A, the windpipe; B, the bronchial tubes.

difference between vocalization and non-vocalization is seen in a sigh and a groan, the latter being the former vocalized. Whistling is a pure mouth-sound, and does not depend on the voice. Laughter is vocal, being the aspirated vowels, *a*, *e*, or *o*, convulsively repeated.

without interrupting the current of air by various modifications of the vocal organs. In sounding singly any one of the letters, we can detect its peculiar requirements. Thus *m* and *n* can be made only by blocking the air in the mouth and sending it through the nose; *l* lets the air escape at the sides of the tongue; *r* needs a vibratory movement of the tongue; *b* and *p* stop the breath at the lips; *d* and *t*, at the back of the palate. Consonants like *b* and *d* are abrupt, or, like *l* and *s*, continuous. Those made by the lips are termed *labials*; those by pressing the tongue against the teeth, *dentals*; those by the tongue, *linguals*.

The child gains speech slowly, first learning to pronounce the vowel *a*, the consonants *b*, *m*, and *p*, and then their unions, *ba*, *ma*, *pa*.

Description of the Organs of Respiration.—Beneath the larynx is the wind-pipe, or *trachea*, so called because of its roughness. It is strengthened by *C*-shaped cartilages with the openings behind, where they are attached to the oesophagus. At the lower end the trachea divides into two branches, called the right and left *bronchi*. These subdivide into the small bronchial tubes, which ramify through the lungs like the branches of a tree, the tiny twigs of which at last end in clusters of cells so small that there

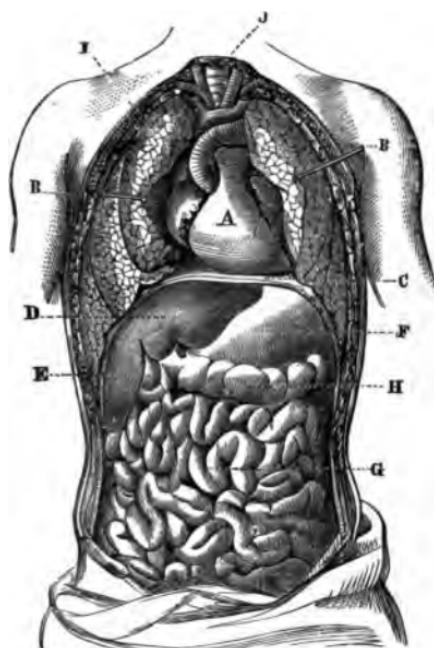
Fig. 50



Bronchial Tuber, with clusters of cells.

are 600,000,000 in all. This cellular structure renders the lungs exceedingly soft, elastic, and sponge-like.* The stiff, cartilaginous rings so noticeable in the rough surface of the trachea and the bronchi disappear as we reach the smaller bronchial tubes, so that while the former are kept open for the free admission of air, the latter are pro-

Fig. 31.



A, the heart; B, the lungs drawn aside to show the internal organs; C, the diaphragm; D, the liver; E, the gall cyst; F, the stomach; G, the small intestine, H, the transverse colon.

* The lungs of slaughtered animals are vulgarly called "lights," probably on account of their lightness. They are similar in structure to those of man. They will float on water, and if a small piece be forcibly squeezed between the fingers (notice the creaking sound it gives), it will still retain sufficient air to make it buoyant.

vided with numerous muscular fibres by which they may be opened or closed at will.

Wrappings of the Lungs.—The lungs are invested with a double covering—the *pleura*—one layer being attached to the lungs and the other to the walls of the chest. It secretes a fluid which lubricates it, so that the layers glide upon each other with perfect ease. The lungs are lined with mucous membrane, exceedingly delicate and sensitive to the presence of anything except pure air. We have all noticed this when we have breathed anything offensive.

The Cilia.—Along the bronchial tubes are minute hair-like bodies (*cilia*), which are in constant motion, like a field of grain stirred by a gentle breeze. They serve to fan the air in the lungs, and produce an outward current, which is useful in catching dust and fine particles swept inward with the breath.

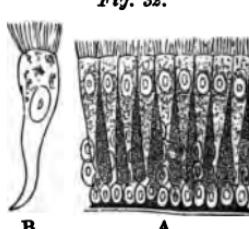


Fig. 32.

A, a section of the mucous membrane, showing the cilia; B, more highly magnified.

How We Breathe.—Respiration consists of two acts—taking in the air, or *inspiration*, and expelling the air, or *expiration*.

1. *Inspiration.*—When we draw in a full breath, we straighten the spine and throw the head and shoulders back, so as to give the greatest advantage to the muscles.*

* If we examine the bony cage of the thorax or chest in Fig. 8, we shall see that the position of the ribs may alter its capacity in two ways. 1. As they run obliquely downward from the spine, if the sternum or breast-bone be lifted in front, the diameter of the chest will be increased. 2. The ribs are fastened by elastic cartilages, which stretch as the muscles that lift the ribs contract, and so increase the breadth of the chest.

At the same time the diaphragm* descends and presses the walls of the abdomen outward. Both these processes increase the size of the chest. Thereupon the elastic lungs expand † to occupy the extra space, while the air, rushing in through the windpipe, pours along the bronchial tubes and crowds into every cell.

2. *Expiration.*—When we forcibly expel the air from our lungs, the operation is reversed. We bend forward, draw in the walls of the abdomen, and press the diaphragm upward, while the ribs are pulled downward—all together diminishing the size of the chest, and forcing the air outward.

Ordinary, quiet breathing is performed mainly by the diaphragm—one breath to every four beats of the heart, or eighteen per minute.

Modifications of the Breath.—*Sighing* is merely a prolonged inspiration followed by an audible expiration. *Coughing* is a violent expiration in which the air is driven through the mouth. *Sneezing* differs from coughing, the air being forced through the nose. *Snoring* is a sleeping accompaniment, in which the air passes through both nose and mouth. The peculiar sound is produced by the

* The diaphragm is the muscular partition between the chest and the abdomen. It is always convex toward the former and concave toward the latter. (See Fig. 31.) Long muscles extend from its centre toward the ribs in front and the spine at the back. When these contract, they depress and flatten the diaphragm; when they relax, it becomes convex again. In the former case, the bowels are pressed downward and the abdomen pushed outward; in the latter, the bowels spring upward, and the abdomen is drawn inward.

† It is said that in drawing a full breath, the muscles exert a force equal to raising a weight of 750 lbs. When we are about to make a great effort, as in striking a heavy blow, we naturally take a deep inspiration, and shut the glottis. The confined air makes the chest tense and firm, and enables us to exert a greater force. As we let slip the blow, the glottis opens and the air escapes, often with a curious aspirated sound, as is noticeable in workmen. To make a good shot with a rifle, we should take aim with a full chest and tight breath, since then the arms will have a steadier support.

palate flapping in this divided current of air, and so throwing it into vibration. *Laughing* and *crying* are very much alike. The expression of the face is necessary to distinguish between them. The sounds are produced by short, rapid contractions of the diaphragm. *Hiccup* is confined to inspiration. It is caused by a contraction of the diaphragm and a constriction of the glottis. *Yawning*, or *gaping*, is like sighing.* It is distinguished by a wide opening of the mouth and a deep, profound inspiration. Both processes furnish additional air, and therefore probably meet a demand of the system for more oxygen. Frequently, however, they are, like laughing, sobbing, etc., merely a sort of contagion, which runs through an audience, and seems almost irresistible.

The Capacity of the Lungs.—If we take a deep inspiration, and then forcibly exhale all the air we can expel from the lungs, this amount, which is termed the *breathing capacity*, will bear a very close correspondence to our stature. For a man of medium height (5 ft. 8 in.) it will be about 230 cubic inches,† or a gallon, and for each inch of height between five and six feet there will be an increase of eight cubic inches.—HUTCHINSON. In addition, it is found that the lungs contain about 100 cubic inches which cannot be expelled, thus making their entire contents about 330 cubic inches, or eleven pints.

* Their usefulness lies in bringing up the arrears, as it were, of respiration, when it has fallen behindhand either through fatigue or close attention to other occupation. The stretching of the jaws and limbs may also serve to equalize the nervous influence, certain muscles having become uneasy on account of being stretched or contracted for a long time.

† Of this amount 100 cubic inches can be forced in only by an extra effort, and is available for emergencies, or for purposes of training, as in singing, climbing, etc. It is of great importance, since, if the capacity of the lungs only equaled our daily wants, the least obstruction would prove fatal.

The extra amount always on hand in the lungs is of great value, since thereby the action of the air goes on continuously, even during a violent expiration.

The Need of Air.—The body needs food, clothing, sunshine, bathing, and drink; but none of these wants is so pressing as that for air. The other demands may be met by occasional supplies, but air must be furnished every moment or we die. Now the vital element of the atmosphere is oxygen gas.* This is a stimulating, life-giving principle. No tonic will so invigorate as a few full, deep breaths of cold, pure air. Every organ will glow with the energy of the fiery oxygen.

Action of the Air in the Lungs.—In the delicate cells of the lungs the air gives up its oxygen to the blood, and receives in turn carbonic acid gas and water, foul with waste matter which the blood has picked up in its circulation through the body. The blood, thus purified and laden with the inspiring oxygen, goes bounding through the system, while the air we exhale carries off the impurities. In this process the blood changes from purple to red, while if we examine our breath we can readily see what it has removed from the blood.

Tests of the Breath.—1. Breathe into a jar, and on lowering into it a lighted candle, the flame will be instantly extinguished; thus indicating the presence of carbonic acid gas. 2. Breathe upon a mirror, and a film of moisture will show the vapor. 3. If the breath be confined in a bottle for a time, the animal matter will decompose and give off an offensive odor.

* See *Chemistry*, page 48. The atmosphere consists of one-fifth oxygen and four-fifths nitrogen. The former is the active element, and the latter the passive. Oxygen alone would be too stimulating, and must be restrained by the neutral nitrogen.

Our breath is then air robbed of its vitality, and containing in its place a gas which is as fatal to life * as it is to a flame, and effete matter which at the best is disagreeable to the smell, injurious to the health, and may contain the germs of disease.

The Evil Effect of Re-breathing the air cannot be over-estimated. We take back into our bodies that which has just been rejected. The blood thereupon leaves the lungs, bearing, not the invigorating oxygen, but refuse matter to obstruct the whole system. We soon feel the effect. The muscles become inactive. The blood stagnates. The heart acts slowly. The food is undigested. The brain is clogged. Instances of fatal results are only too frequent.† The constant breathing of even the slightly impure air of our houses cannot but tend to undermine the health. The blood is not purified, and is thus in a condition to receive the seeds of disease at any time.‡ The system uninspired by the energizing oxygen

* Carbonic acid gas cannot be breathed when undiluted, as the glottis closes and forbids its passage into the lungs. Air containing only three or four per cent. acts as a narcotic poison (MILLER), and a much smaller proportion will have an injurious effect. The great danger, however, lies in the organic particles constantly exhaled from the lungs and the skin.

† During the English war in India in the last century, 146 prisoners were shut up in a room scarcely large enough to hold them, into which the air could only enter by two narrow windows. At the end of eight hours but twenty-three remained alive, and these were in most deplorable condition. This prison was well called "The Black Hole of Calcutta."—Percy relates that after the battle of Austerlitz, 300 Russian prisoners were confined in a cavern, where 260 of them perished in a few hours.—The stupid captain of the ship Londonderry, during a storm at sea, shut the hatches. There were only seven cubic feet of space left for each person, and in six hours ninety of the passengers were dead.

‡ The floating dust in the air, revealed to us by the sunbeam shining through a crack in the blinds, shows the abundance of these impurities, and also the presence of germs which, lodging in the lungs, may implant disease, unless thrown off by a vigorous constitution. "On uncovering a scarlet-fever patient, a cloud of fine dust is seen to rise from the body—contagious dust, that for days will retain its poisonous properties."—YOUmans.

is sensitive to cold. The pale cheek, the lustreless eye, the languid step, speak but too plainly of oxygen starvation. In such a soil catarrh, scrofula, and consumption run riot.*

Concerning Ventilation.—The foul air which passes off from the lungs and through the pores of the skin does not fall to the floor, but diffuses itself through the surrounding atmosphere. A single breath, therefore, will to a trifling but certain extent taint the air of a whole room.†

A light or a fire will vitiate as much air as a dozen persons. It is now fully established that carbonic oxide gas—a product of combustion still more deadly than carbonic acid gas—leaks out from a stove through the pores of the hot iron. Thus, besides the air which a stove withdraws from a room, it actually poisons that which we breathe. Many breaths and lights rapidly unfit the air for our use.

The perfection of ventilation is reached when the air of a room is as pure as that out of doors. To accomplish this result it is necessary to allow for each person 800 cubic feet of space, while ventilation is still going on in the best manner known.

In spite of these well-known facts, scarcely any pains are taken to supply fresh air, while the doors and windows where the life-giving oxygen might creep in are hermetically stopped.

* "One not very strong, or unable powerfully to resist conditions unfavorable to health, and with a predisposition to lung disease, will be sure, sooner or later, by partial lung-starvation and blood-poisoning, to develop pulmonary consumption. The lack of what is so abundant and so cheap—good, pure air—is unquestionably the one great cause of this terrible disease."—*Ten Laws of Health.*—BLACK.

† This grows out of a well-known philosophical principle called the Diffusion of Gases, whereby two gases tend to mix in exact proportions, no matter what may be the quantity.—*Chemistry*, p. 96, and *Physics*, p. 49.

Our school-rooms, heated by furnaces or red-hot stoves, often have no means of ventilation, or, if provided, they are seldom used. A window is occasionally dropped to give a little relief, as if pure air were a rarity, and must be doled out to the suffering lungs in morsels, instead of full and constant draughts. Pupils starved by scanty lung-food, and stupefied by foul air, become listless and dull. The process goes on year by year. The weakened and poisoned body at last succumbs to disease, while we in our blindness and ignorance talk of the mysterious Providence which thus untimely cuts down the brightest intellects. The truth is, death is often simply the penalty of violating nature's laws. Bad air begets disease; disease begets death.

In our churches the foul air left by the congregation on Sunday is shut up during the week, and heated for the next Lord's day, when the people assemble to re-breathe the polluted atmosphere. They are thus forced, with every breath they take, to violate the physical laws of Him whom they meet to worship—laws written not 3000 years ago upon Mount Sinai on tables of stone, but to-day engraved in the constitution of their own living, breathing bodies. On brains benumbed and starving for oxygen, the purest truth and the highest eloquence fall with little force.

We sleep in a bed-room from which every breath of fresh air is excluded, because we believe night-air to be unhealthy, and so we breathe its half-dozen hogsheads of air over and over again, and then wonder why we awaken in the morning so dull and unrefreshed! Return to our room after inhaling the fresh, morning air, and the fetid

odor we meet on opening the door will soon convince us how we have poisoned our lungs during the night.

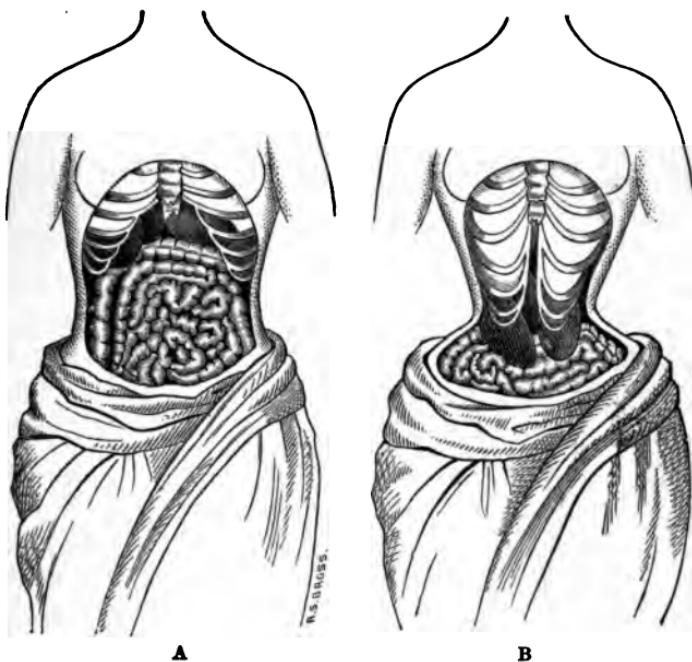
Each room should be supplied with 2000 feet of fresh air per hour for every person it contains. Our ingenuity will find some way of doing this most advantageously and pleasantly. A moiety of the care we devote to delicate articles of food, drink, and dress will abundantly meet this prime necessity of our bodies.

Open the window a little at the top and bottom. Put on plenty of clothing to keep warm by day and by night, and then let the inspiring oxygen come in as freely as God has given it. Pure air is the cheapest necessity and luxury of life. Let it not be the rarest!

Wonders of Respiration.—The perfection of the organs of respiration challenges our admiration. So delicate are they that the least pressure would cause exquisite pain, yet tons of air surge to and fro through their intricate passages, and bathe their innermost cells. We yearly perform at least 7,000,000 acts of breathing, inhaling 100,000 cubic feet of air, and purifying over 3,500 tons of blood. This gigantic process goes on constantly, never wearies or worries us, and we only wonder at it when science reveals to us its magnitude. In addition, by a wise economy, the process of respiration is made to subserve a second use no less important, and the air we exhale, passing through the organs of voice, is transformed into prayers of faith, songs of hope, and words of social cheer.

Diseases, etc.—1. *Constriction of the Lungs* is produced by tight clothing. The ribs are thus forced inward, the size of the chest diminished, and the amount of inhaled air decreased. A garment which will not admit of a full breath without inconvenience, and even stiff

Fig. 33.



A, the natural position of the internal organs. B, when deformed by tight lacing. MARSHALL says that the liver and the stomach have, in this way, been forced downward almost as low as the pelvis.

clothing, will prevent that free movement of the ribs so essential to health. Any infraction of the laws of respiration, even though it be fashionable, will result in diminished vitality and vigor, and will be fearfully punished by sickness and weakness through the whole life.

2. **Bronchitis** is an inflammation (see *Inflammation*) of the mucous membrane of the bronchial tubes. It is accompanied by an increased secretion of mucus, and consequent coughing.

3. **Pleurisy** is an inflammation of the pleura. It is sometimes caused by an injury to the ribs, and results in a secretion of water within this membrane.

4. **Pneumonia** (*pneuma*, breath) is an inflammation of the lungs, affecting chiefly the air-cells.

5. **Consumption** is a disease which destroys the substance of the lungs. Like other lung difficulties, it is caused largely by want of pure air, a liberal supply of which is the best treatment that can be prescribed for it.*

6. **Asphyxia** (as-fix'-i-a). When a person is drowned, strangled, or choked in any way, what is called asphyxia occurs. The face turns black; the veins become turgid; insensibility and often convulsions ensue. If relief is not secured within a few minutes, death will be inevitable.† (See Appendix.)

7. **Diphtheria** (*diphthera*, a membrane) is a kind of sore-throat, in which matter exudes from the mucous membrane. This stiffens into a peculiar white substance, patches of which may be seen in the back part of the mouth. Fever and debility accompany this disease, which is so sudden and insidious in its advances as to be exceedingly dreaded. (See Appendix.)

8. **Croup**, which often attacks young children, is an inflammation of the mucous membrane of the larynx and trachea. It is commonly preceded by a cold. The child

* "If I were seriously ill of consumption, I would live out-doors day and night, except in rainy weather or mid-winter; then I would sleep in an un-plastered log-house. Physic has no nutriment, gaspings for air cannot cure you, monkey capers in a gymnasium cannot cure you, and stimulants cannot cure you. What consumptives want is pure air, not physic—pure air, not medicated air—plenty of meat and plenty of bread."—DR. MARSHALL HALL.

† The lack of oxygen, and the presence of carbonic acid gas, are the combined causes. Oxygen starvation, and carbonic acid poisoning, each fatal in itself, work together to destroy life.

sneezes, coughs, and is hoarse, but the attack frequently comes on suddenly, and usually in the night. It is accompanied by a peculiar "brassy," ringing cough, which, once heard, can never be mistaken. It may prove fatal within a few hours. (See Appendix.)

9. *Stammering* depends, not on faults of the muscles, but on a want of due control of the mind. When a stammerer is not too conscious of his lack, and tries to form his words slowly, he speaks plainly, and may sing well, for then his words must come in time. Many persons who stutter in common conversation can talk with much fluency when making a speech. The stammerer should find out his peculiar defect, and overcome it by exercise, and especially by speaking only after a full inspiration.

PRACTICAL QUESTIONS.

1. What is the philosophy of the "change of voice" in a boy?
2. Why can we see our breath on a frosty morning?
3. When a law of health and a law of fashion conflict, which should we obey?
4. If we use a "bunk" bed, should we pack away the clothes when we first rise in the morning?
5. Why should a clothes-press be well-ventilated?
6. Should the weight of our clothing hang from the waist or the shoulder?
7. Describe the effects of living in an over-heated room?
8. What habits impair the power of the lungs?
9. For full, easy breathing in singing, should we use the diaphragm and lower ribs or the upper ribs alone?
10. Why is it better to breathe through the nose than the mouth?
11. Why should not a speaker talk while returning home on a cold night after a lecture?
12. What part of the body needs the loosest clothing?
13. What part needs the warmest?

14. Why is a "spare bed" generally unhealthful?
15. Is there any good in sighing?
16. Should a hat be thoroughly ventilated? How?
17. Why do the lungs of people who live in cities become of a gray color?
18. How would you convince a person that a bed-room should be aired?
19. What persons are most liable to scrofula, consumption, etc.?
20. If a person is plunged under water, will any enter his lungs?
21. Are bed-curtains healthful?
22. Why do some persons take "short breaths" after a meal?
23. What is the special value of public parks?
24. Can a person become used to bad air, so that it will not injure him?
25. Why do we gape when we are sleepy?
26. Is a fashionable waist a model of art in sculpture or painting?
27. Should a fire-place be closed?*
28. Why does embarrassment or fright cause a stammerer to stutter still more painfully?
29. In the organs of voice, what parts have somewhat the same effect as the case of a violin and the sounding-board of a piano?

* "Thousands of lives would be saved if all fire-places were kept open. If you are so fortunate as to have a fire-place in your room, paint it when not in use; put a bouquet of fresh flowers in it every morning, if you please, or do anything to make it attractive, but never *close it*; better use the fire-boards for kindling-wood. It would be scarcely less absurd to take a piece of elegantly-tinted court-plaster and stop up the nose, trusting to the accidental opening and shutting of the mouth for fresh air, because you thought it spoiled the looks of your face to have two such great, ugly holes in it, than to stop your fire-place with elegantly-tinted paper because it looks better."—LEMDS.

STANFORD LIBRARY

V.

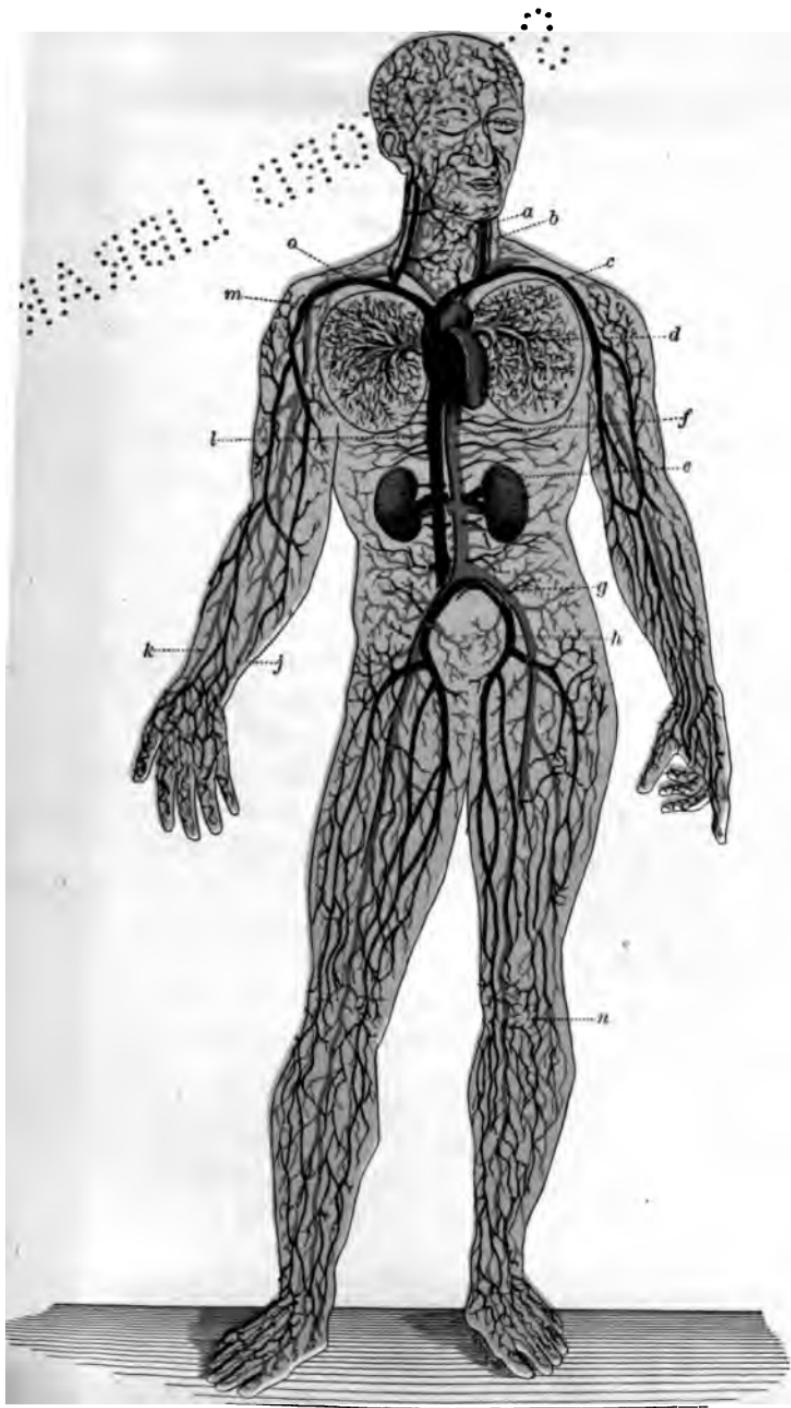
CIRCULATION.

“No rest this throbbing slave may ask,
For ever quivering o'er his task,
While far and wide a crimson jet
Leaps forth to fill the woven net,
Which in unnumber'd crossing tides
The flood of burning life divides,
Then, kindling each decaying part,
Creeps back to find the throbbing heart.”

HOLMES.

Marcel Agnoletto

STANFORD LIBRARY



THE CIRCULATION.

THE Organs of the Circulation are the *heart*, the *arteries*, the *veins*, and the *capillaries*.

The Blood is the liquid by means of which the circulation is effected. It permeates every part of the body, except the cuticle, nails, hair, etc. The average quantity

Fig. 35.



A, human blood, highly magnified; B, the blood of an animal.



in each person is about eighteen pounds. It is composed of a thin, colorless liquid, the *plasma*, filled with red disks or cells,* so small that 3,500 placed side by side would

* There is also one white globular cell to every three or four hundred red ones. The blood is no more red than the water of a stream would be if you were to

only measure an inch, and it would take 18,000 laid flat-wise upon one another to make a column of that height. Under the microscope, they are found to be rounded at the edge and concave on both sides.* They have a tendency to collect in piles like rolls of coin. They vary in size and shape in the blood of different animals.† This fact is of great value in criminal trials, since blood-stains on garments or weapons reveal, under the microscope, whether they are from human beings or from animals.‡ Disks are continually forming in the blood, and as constantly dying —20,000,000 at every breath.—DRAPER. The plasma also

fill it with little red fishes. Suppose the fishes to be very, very small—as small as a grain of sand—and closely crowded together through the whole depth of the stream; the water would look quite red, would it not? And this is the way in which blood looks red—only observe one thing; a grain of sand is a mountain in comparison with the little red fishes in the blood. If I were to tell you they measured about $\frac{1}{100}$ of an inch in diameter, you would not be much wiser; so I prefer saying (by way of giving you a more perfect idea of their minuteness) that there would be about a million in such a drop of blood as would hang on the point of a needle. I say so on the authority of a scientific microscopist—M. Boullet. Not that he has ever counted them, as you may suppose, any more than I have done; but this is as near an approach as can be made by calculation to the size of $\frac{1}{100}$ part of an inch in diameter.—JEAN MAIE.

* By pricking the end of the finger with a needle, we can obtain a drop for examination. Place it on the slide, cover with a glass and put it at once under the microscope. The red disks will be seen to group themselves in rows, while the white disks will seem to draw apart and to be constantly changing their form. After a gradual evaporation, the crystals (Fig. 86) may be seen. In animals they have various, though distinctive forms.

† The following is the size of the cells (corpuscles) in different animals. Cat, $\frac{1}{100}$ of an inch in diameter; whale, $\frac{1}{100}$; mouse, $\frac{1}{100}$; hog, $\frac{1}{100}$; camel, $\frac{1}{100}$; sheep, $\frac{1}{100}$; horse, $\frac{1}{100}$; Virginia deer, $\frac{1}{100}$; dog-faced baboon, $\frac{1}{100}$; brown baboon, $\frac{1}{100}$; red monkey, $\frac{1}{100}$; black monkey, $\frac{1}{100}$; perch, $\frac{1}{100}$; eel, $\frac{1}{100}$.—GULLIVER'S TABLES.

‡ In one case it is said that the small quantity lodged in the eye of an axe between the metal and the wood, although the weapon had been carefully cleaned, answered for examination and the consequent conviction of the murderer. In connection with the statement of the text, it should be noticed that recent investigations have thrown great doubt upon the reliability of this test. The best microscopists declare that it is impossible to determine accurately whether a given specimen of blood is of human or of animal origin. Further research is needed fully to settle this point.

Fig. 36.



Blood Crystals.

contains fibrin—which is merely a solution of lean meat, albumen—such as is found nearly pure in the white of an egg, and also various mineral substances, as iron,* lime, magnesia, phosphorus, soda, potash, etc.

Uses of the Blood.—The blood has been called “liquid flesh;” but it is more than that, since it contains the materials for making every organ. The plasma is rich in mineral matter for the bones, and in albumen for the muscles. The red disks are the air-cells of the blood. They contain the oxygen so essential to every operation of life. Wherever there is work to be done or repairs to be made, there the oxygen is needed. It stimulates to action, and tears down all that is worn out. In this process it combines with and actually burns out parts of the muscles and other tissues, as wood is burned in the stove.

* Enough iron has been found in the ashes of a burned body to form a “mourning ring.”

The blood, now foul with the burned matter, the refuse of this fire, is caught up by the circulation and whirled back to the lungs, where it is purified, and again sent bounding on its way.

Transfusion.—As the blood is really the “vital fluid,” efforts have been made to restore the feeble by infusing healthy blood into their veins. If blood be drawn from an animal until it is seemingly dead, and then that from another animal be injected into its veins, its vitality will be restored.* This practice became quite common in the seventeenth century. The operation was even tried on human beings, and the most extravagant hopes were entertained. A maniac was restored to reason by the blood of a calf. But many fatal accidents occurring, it was forbidden by law, and soon fell into disuse. It has, however, been successfully practiced in New York in two or more cases within the last two years, and is a method still in repute for saving life.

Coagulation.—When blood is exposed to the air, it coagulates. This is caused by the hardening of the fibrin, which, entangling the red disks, forms the “clot.” The remaining clear, yellow liquid is the *serum*. The value of this peculiar property of the blood can hardly be overestimated. The coagulation soon checks all ordinary cases of bleeding.† When a wound is made, and bleeding commences, the fibrin forms a temporary plug, as it were, which is absorbed when the healing process is finished.‡

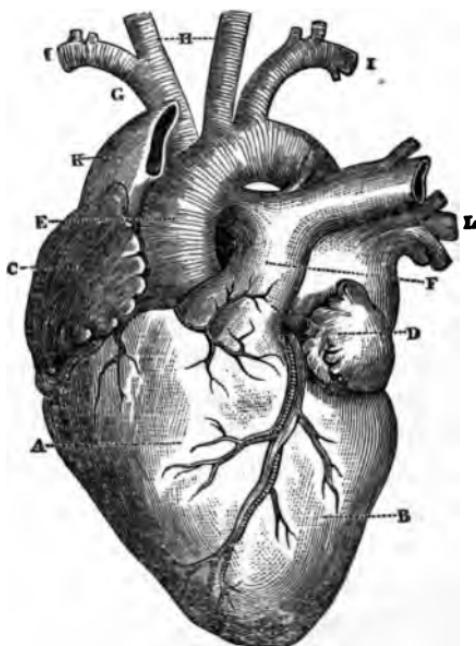
* Brown-Séguard tells of a curious instance in which the blood of a living dog was transferred into one just dead. The animal rose on its feet and wagged its tail, but died a second time twelve and one-half hours afterward.

† In the case of the lower animals, which have no means of stopping hemorrhage as we have, the coagulation is more rapid, and with insects it is almost instantaneous.

‡ The fibrin is not an essential ingredient of the blood. All the functions of

Thus we see how a Divine foresight has provided not only for the ordinary wants of the body, but also for the accidents to which it is liable.

Fig. 57.



The Heart. A, the right ventricle; B, the left ventricle; C, the right auricle; D, the left auricle.

The Heart is the engine which propels the blood. It is a hollow, pear-shaped muscle, about the size of the fist. It hangs, point downward, just to the left of the centre of

life are regularly performed in people whose blood lacks fibrin; and in cases of transfusion, where blood deprived of its fibrin was used, the vivifying influence seemed to be the same. Its office, therefore must mainly be to stanch any hemorrhage which may occur.—FLINT.

the chest. (See Fig. 31.) It is enclosed in a loose sac of serous membrane,* called the pericardium (*peri*, about; and *cardia*, the heart). This secretes a lubricating fluid, and is smooth as satin.

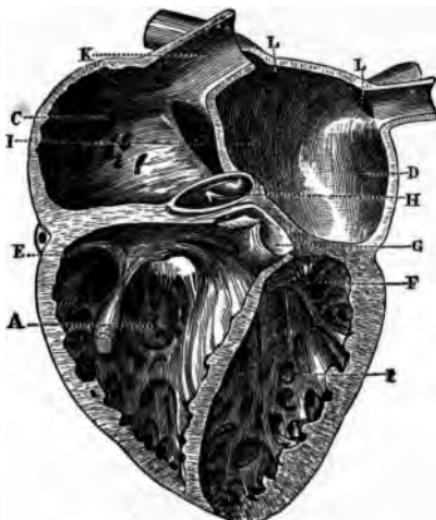
The Movements of the Heart consist of an alternate contraction and expansion. The former is called the *systole*, and the latter the *diastole*. During the diastole the blood flows into the heart, to be expelled by the systole. The alternation of these movements constitutes the beating of the heart which we hear so distinctly between the fifth and sixth ribs.†

The Auricles and Ventricle.—The heart is divided into four chambers. In an adult, each holds about a wine-glassful. The upper ones, from appendages on the outside resembling the ears of a dog, are called *auricles* (*aures*, ears); the lower ones are termed *ventricles*. The auricle and ventricle on each side communicate with each other, but the right and left halves of the heart are entirely distinct, and perform different offices. The left side

* The mucous membrane lines the open cavities of the body, the serous the closed. The pericardium is a sac composed of two layers—a fibrous membrane on the outside, and a serous one on the inside. The latter covers the external surface of the heart, and is reflected back upon itself in order to form, like all the membranes of this nature, a sac without an opening. The heart is thus covered by the pericardial sac, but not contained inside its cavity. A correct idea may be formed of the disposition of the pericardium around the heart by recalling a very common and very convenient, though now discarded head-dress, the cotton night-cap. The pericardium encloses the heart exactly as this cap covered our forefathers' heads.—*Wonders of the Human Body*.

† "Two sounds are heard if we put our ear over the heart—the first and longer as the blood is leaving the organ, the second as it falls into the pockets of the two arteries, and the valves then striking together cause it. The first sound is mainly the noise made by the muscular tissue. During the first, the two ventricles contract; during the second, the two auricles do so. The hand may feel the heart striking the ribs as it contracts—a feeling called the impulse, or, if quicker and stronger than usual, palpitation. This is not always a sign of disease, but in hypochondriacs is often an effect of the mind on the nerves of the heart."—*MAPOTHEC*.

FIG. 33.



Chambers of the Heart. A, right ventricle; B, left ventricle; C, right auricle; D, left auricle; E, tricuspid valve; F, bicuspid valve; G, semi-lunar valves; H, valve of the aorta; I, inferior vena cava; K, superior vena cava; L, L, pulmonary veins.

propels the red blood, and the right the dark. The auricles are merely reservoirs to receive the blood—the left auricle, as it filters in bright and pure from the lungs; the right, as it returns dark and foul from the tour of the body—and to furnish it to the ventricles as they need. Their work being so light, their walls are comparatively thin and weak. On the other hand, the ventricles force the blood—the left, to all parts of the body; the right, to the lungs—and are, therefore, made very strong. As the left ventricle drives the blood so much further than the right, it is correspondingly thicker and stronger.

Need of Valves in the Heart.—As the auricles do not need to contract with much force simply to empty

Fig. 29.

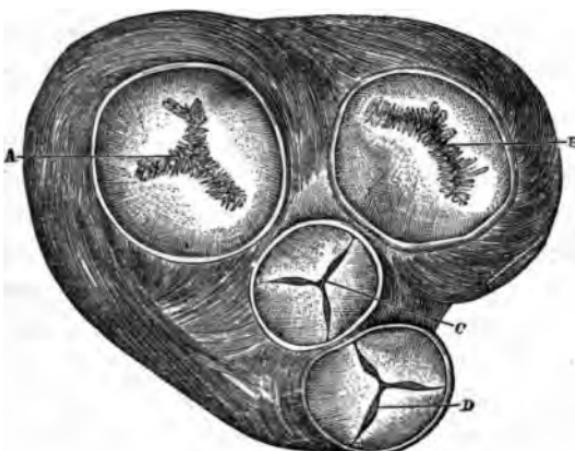


Diagram showing the peculiar Fibrous Structure of the Heart and the Shape of the Valves. A, tricuspid valve; B, bicuspid valve; C, semi-lunar valves of the aorta; D, semi-lunar valves of the pulmonary artery

their contents into the ventricles below them, there is no necessity for any special contrivance to prevent the blood from setting back the wrong way. Indeed, it would naturally run down into the ventricle, which is at that moment open to receive it. But when the strong ventricles contract, especially the left one, which must drive the blood to the extremities, some arrangement is necessary to prevent its escaping into the auricle again. Besides, when they expand, the "suction power" would tend to draw back again from the arteries all the blood just forced out. This difficulty is obviated by means of little doors or valves, which will not let it go the wrong way.*

* The heart of an ox or a sheep may be used to show the chambers and valves. The aorta should be cut as far as possible from the heart, and then by pumping in water the perfection of these valves will be finely exhibited. Cutting the heart across near the middle will show the greater thickness of the left ventricle.

The Tricuspid and Bicuspid Valves.—At the opening into the right ventricle is a valve consisting of three folds or flaps of membrane, whence it is called the *tricuspid* valve (*tri*, three; and *cuspides*, points), and in the left ventricle, one containing two flaps, and named the *bi-cuspid* valve. These hang so loosely as to oppose no resistance to the passage of the blood into the ventricles; but if any attempts to go the other way, it gets between the flaps and the walls of the heart, and, driving them outward, closes the orifice.

These Flaps are Strengthened like sails by slender cords, which prevent their being pressed back through the opening. If the cords were attached directly to the walls of the heart, they would be loosened in the systole, and so become useless when most-needed. They are, therefore, fastened to little muscular pillars projecting from the sides of the ventricle; when that contracts the pillars contract also, and thus the cords are held tight.

The Semi-lunar Valves.—In the passages out from the ventricles are valves, called from their peculiar half-moon shape *semi-lunar* valves (*semi*, half; *Luna*, Moon). Each consists of three little pocket-shaped folds of membrane, with their openings in the direction which the blood is to take. When it sets back, they fill, and, swelling out, close the passage. (See Fig. 40.)

The Arteries* are the tube-like canals which convey the blood from the heart to nourish the system. They carry only the red blood. (Fig. 34.) They are composed of an elastic tissue, which yields at every throb of the

* *Aer*, air; and *terein*, to contain—so named because after death they contain air only, and hence the ancients supposed them to be air-tubes leading through the body.

heart, and then slowly contracting again, keeps up the motion of the blood until the next systole. The elasticity of the arteries acts like the air-chamber of a fire-engine, which converts the intermittent jerks of the brakes or pump into the steady stream of the hose-nozzle. The arteries communicate with one another by branches or by meshes of loops, so that if the blood be blocked in one, it can pass round through another, and so get by the obstacle.* When an artery penetrates a muscle, it is often protected by a sheath or by fibrous rings, which prevent its being pulled out of place or compressed by the play of the muscles. The arteries are generally located as far as possible beneath the surface, out of harm's way, and hence are found closely hugging the bones or creeping through safe passages provided for them. They are generally nearly straight, and take the shortest routes to the parts which they are to supply with blood.

The **Arterial System** starts from the left ventricle by a single trunk—the *aorta*—which, after giving off branches to the head, sweeps back of the chest with a bold curve—the *arch of the aorta* (*c*, Fig. 34)—and thence runs downward (*f*), dividing and subdividing, like a tree, into numberless branches, which, at last, penetrate every nook and corner of the body.

The **Pulse**.—At the wrist (*k*, radial artery) and on the temple (temporal artery) we can feel the expansion of the artery by each little wave of blood set in motion by the contraction of the heart. In health, there are about

* This occurs especially about the joints, where it serves to maintain the circulation during the bending of a limb, or when the main artery is obstructed by disease or injury, or has been tied by the surgeon. In the last case, the small adjacent arteries gradually enlarge, and form what is called a collateral circulation.

seventy-two* pulsations per minute. They increase with excitement or inflammation, weaken with loss of vigor, and are modified by nearly every disease. The physician, therefore, finds the pulse a good index of the state of the system and character of the disorder.

The Veins are the channels by which the blood returns to the heart.† They, therefore, carry the dark or venous blood. As they do not receive the direct impulse of the heart, their walls are made much thinner and less elastic than those of the arteries. At first small, they increase in size and diminish in number as they gradually empty into one another, like the tiny rills which collect to form a river, which, by two mouths, the *vena cava* ascending and *vena cava* descending (*l, m*, Fig. 34), empties into the right auricle. One set of the veins creep along under the skin, where they can be seen, as in the back of the hand; another set accompany the arteries, some of which have two or more of these satellites.

Valves similar in construction to those already described (the semi-lunar valves of the heart) are placed at convenient intervals, especially in the lower extremities, to guide the blood in its course, and prevent its setting backward.‡ We can easily examine the working of these

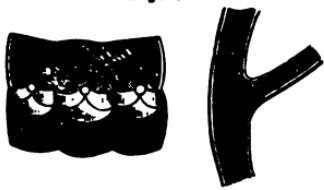
* This number varies much with age, sex, and individuals. Napoleon's pulse is said to have been only 40, while it is not infrequent to find a healthy pulse at 100 or over. Shame makes the heart send more blood to the blushing cheek, and fear almost stops it. The will cannot check the heart. There is said, however, to have been a notable exception to this in the case of one Col. Townsend, of Dublin, who, after having succeeded several times in stopping the pulsation, at last lost his life in the act.

† There is one exception to the general course of the veins. The *portal* vein carries the blood from the digestive organs to the liver, where it is acted upon, thence poured into the ascending *vena cava*, and goes back to the heart. (See page 145.)

‡ "Too much standing, or tight elastics, often swell and spoil the valves of the veins in the leg; they then become *varicose*, or permanently enlarged, and if they burst, the bleeding may be profuse and even dangerous. Raising

valves. On baring the arm, blue veins may be seen running along the arm toward the hand. Their diameter is

Fig. 40.



Valves of the Veins.

tolerably even, and they gradually decrease in size. If now the finger be pressed on the upper part of one of these veins, and then passed downward so as to drive its blood backward, swellings like little knots will make

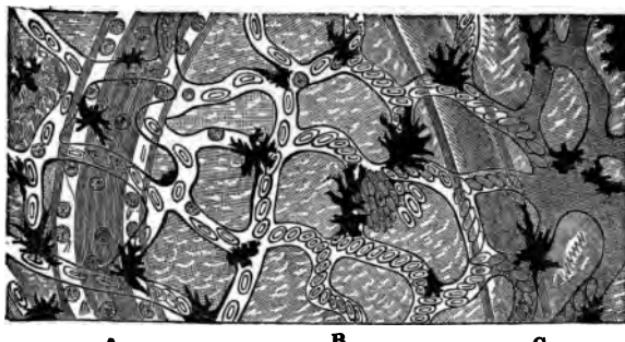
their appearance. Each of these marks the location of a valve, which is closed by the blood we push before our finger. Remove the pressure, and the valve will swing open, the blood set forward, and the vein relapse to its former size.

The Capillaries (*capillus*, a hair) form a fine net-work of tubes, connecting the ends of the arteries with the veins. They blend, however, with the extremities of these two systems, so that it is impossible to tell just where an artery ends and a vein begins. So closely are they placed, that we cannot prick the flesh with a needle without injuring, perhaps, hundreds of them. The air-cells of the blood deposit there their oxygen, and receive carbonic acid, while in the delicate capillaries of the lungs† they

the leg and pressing the finger on the bleeding spot will stay it. Walking does not encourage this disease, for the muscles force on the venous blood. Clerks who are subject to varicose veins should have seats behind the counters where they may rest when not actually employed. A deep breath helps the flow in the veins, and a wound may suck in air with fatal effect. A maimed horse is most mercifully killed by blowing a bubble of air into the veins of his neck. As the pressure deep in the sea would burst valves, there are none in the whale, and hence a small wound by the harpoon causes him to bleed to death."—**MAPOTHER.**

† The capillary tubes are there so fine that the disks of the blood have to go one by one, and are sadly squeezed at that. However, their elasticity enables them to resume their old shape as soon as they have escaped from this labyrinth.

Fig. 41.



Circulation of the Blood in the Web of a Frog's Foot, highly magnified. A, an artery; B, capillaries crowded with disks, owing to a rupture just above, where the disks are jammed into an adjacent mesh; C, a deeper vein; the black spots are pigment cells.

give up their load of carbonic acid in exchange for oxygen. If, by means of a microscope, we examine the transparent web of a frog's foot, we can trace the route of the blood.* It is an experiment of wonderful interest. The crimson stream, propelled by the heart, rushes through the arteries, until it reaches the intricate meshes of the capillaries. Here it breaks into a thousand tiny rills. We can see the disks winding in single file through the devious passages, darting hither and thither, now pausing, swaying to and fro with an uncertain motion, and anon dashing ahead, until, at last, gathered in the veins, the blood sets steadily back on its return to the heart.

The Circulation† consists of two parts—the *lesser* and the *greater*.

* With small splints and twine, a frog's foot can be easily stretched and tied so that the transparent web can be placed on the table of the microscope.

† The circulation of the blood was discovered by Harvey in 1619. For several years he did not dare to publish his belief. When it became known, he was bitterly persecuted, and his practice as a physician greatly decreased in conse-

Fig. 12.

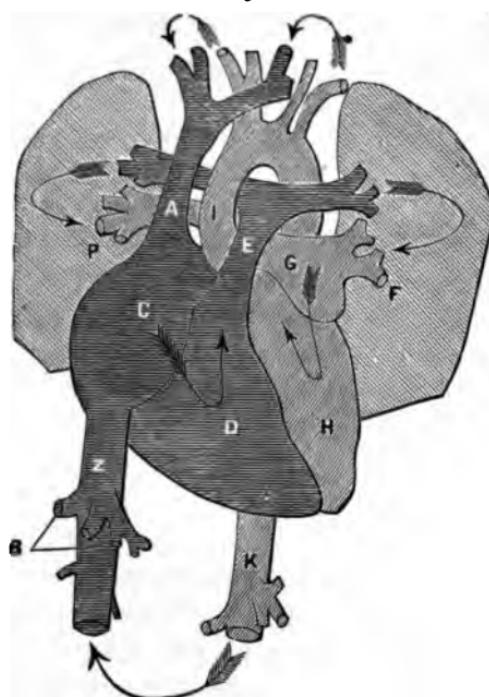


Diagram illustrating the Circulation of the Blood.—MARSHALL. A, vena cava descending (superior); Z, ascending (inferior); C, right auricle; D, right ventricle; E, pulmonary artery; F, lungs and pulmonary veins; G, left auricle; H, left ventricle; I, K, aorta.

1. *The Lesser Circulation.*—The dark blood from the veins collects in the right auricle, and going through the tricuspid valve, empties into the right ventricle. Thence it is driven past the semi-lunar valves, through the pulmonary artery, to the lungs. After circulating through the fine capillaries of the air-cells, it is returned bright

quence. He lived, however, to see his theory universally adopted, and his name honored. Harvey is said to have declared that no man over forty years of age accepted his views.

and red, through the pulmonary veins,* to the left auricle.

2. *The Greater Circulation.*—From the left auricle, it is forced past the bicuspid valve to the left ventricle; thence it is driven through the semi-lunar valves into the great aorta, the main trunk of the arterial system. Passing through the arteries, capillaries, and veins, it returns through the *venæ cavae*, ascending and descending, gathers again in the right auricle, and so completes the "grand round" of the body. Both of these circulations are going on constantly, as the auricles contract and the ventricles expand simultaneously, and *vice versa*.

The Velocity of the Blood varies so much in different parts of the body, and is influenced by so many circumstances, that it cannot be calculated with any degree of accuracy. It has been estimated that a portion of the blood will make the tour of the body in about twenty-three seconds † (FLINT), and that the entire mass passes through the heart in from one to two minutes. ‡

Distribution and Regulation of the Heat of the Body.—1. *Distribution.*—The natural temperature is not far from 98°. § This is maintained, as we have already

* It is noticeable that the pulmonary set of veins circulates red blood, and the pulmonary set of arteries circulates dark blood. Both are connected with the lungs.

† If a salt which can easily be recognized be inserted in one of the jugular veins of a dog, and blood be drawn as quickly as possible from the opposite jugular, the substance will be detected in from twenty to thirty seconds; having passed to the right heart, thence to the lungs, back to the left heart, through the arteries, capillaries, and veins of the face and neck, and into the jugular vein.

‡ The total amount of blood in an adult of average weight is about eighteen pounds. Dividing this by 5 oz., the quantity discharged by the left ventricle at each systole, gives fifty-eight pulsations as the number necessary to transmit all the blood in the body. This, however, is an extremely unreliable basis of calculation, as the rapidity of the blood is itself so variable.

§ "The average temperature is, however, easily departed from. Through

seen, by the action of the oxygen within us. Every capillary tube is a tiny stove, where oxygen is combining with the muscles, tissues, etc., of the body. The heat thus produced is distributed by the circulation of the blood. Thus the arteries, veins, and capillaries form a series of hot-water pipes, through which the heated liquid is forced by a pump—the heart—while the heat is kept up, not by a central furnace and boiler, but by a multitude of little fires placed here and there along its course.

2. Regulation.—The temperature of the body is regulated by means of the pores of the skin and the mucous membrane in the air-passages. When the system becomes too warm, the blood-vessels on the surface expand, the blood fills them, the fluid exudes into the perspiratory glands, pours out upon the exterior, and by evaporation cools the body.* When the temperature of the body is too low, the vessels contract, less blood goes to the surface, the perspiration decreases, and the loss of heat by evaporation diminishes.†

Life by Death.—The body is being incessantly corroded, and portions borne away by the tireless oxygen. The scales of the epidermis are constantly falling off and

some trivial cause the cooling agencies may be interfered with, and then, the heating processes getting the superiority, a high temperature or fever comes on. Or the reverse may ensue. In Asiatic cholera, the constitution of the blood is so changed that its disks can no longer carry oxygen into the system, the heat-making processes are put a stop to, and, the temperature declining, the body becomes of a marble coldness characteristic of that terrible disease."—
DRAPER.

* Just as water sprinkled on the floor cools a room. (*Physics*, page 191.)

† One can go into an oven where bread is baking, or into the arctic regions where the mountains are snow and the rivers ice, with equal impunity. Even by these extremes the temperature of the blood will be but slightly affected. In the one case, the flood-gates of perspiration will be opened and the superfluous heat expended in turning the water to vapor; and in the other, they will be tightly closed and all the heat retained.

being replaced by fresh cells from beneath. The disks of the blood die, and new ones spring into being. On the continuance of this interchange depend our health and vigor. Every act is a destructive one. Not a bend of the finger, not a wink of the eye, not a thought of the brain but is at some expense of the machine itself. Every process of life is thus a process of death. The more rapidly this change goes on, and fresh, vigorous tissue takes the place of the old, the more elasticity and strength we possess.

Change of our Bodies.—There is a belief that our bodies change once in seven years. From the very nature of the case, the rate must vary with the labor we perform, the organs most used altering oftenest. Probably the parts of the body in incessant employment are entirely reorganized many times within a single year.*

The Three Vital Organs.—Death is produced by the stoppage of the action of any one of the three organs—the heart, the lungs, or the brain. They have, therefore, been termed the “Tripod of Life.” Really, however, as Huxley has remarked, “Life has but two legs to stand upon.” If respiration and circulation be kept up artificially, the removal of the brain will not produce death.†

Wonders of the Heart.—The ancients thought the heart to be the seat of love. There were located the purity and goodness as well as the evil passions of the

* To use a homely simile, our bodies are like the Irishman’s knife, which, after having had several new blades, and at least one new handle, was yet the same old knife as ever.

† When death really does take place, i. e., when the vital organs are stopped, it is noticeable that the tissues do not die for some time thereafter. If suitable stimulants be applied, as the galvanic battery, transfusion of blood, etc., the muscles may be made to contract, and many of the phenomena of life be exhibited.

soul.* Modern science has found the seat of all the mental powers to be in the brain. But while it has thus robbed the heart of its romance, it has revealed wonders which eclipse all the mysteries of the past. This marvelous little engine throbs on continually at the rate of 100,000 beats per day, 40,000,000 per year, often 1,000,000,000 without a single stop. It is the most powerful of machines. Its daily work is equal to one-third that of all the muscles. "If it should expend its entire force in lifting its own weight vertically, it would rise 20,000 feet in an hour."† Its vitality is amazing. Lay upon a table the heart from a living sturgeon, all palpitating with life, and it will beat for days as if itself a living creature. The most tireless of organs while life exists, it is one of the last to yield when life expires. As long as a flutter lingers at the heart, we know the spark of being is not quite extinguished, and there is hope of restoration. During a life such as we sometimes see, it has propelled half a million tons of blood, yet repaired itself as it has wasted, during its patient, unfaltering labor. The play of its valves and the rhythm of its throb have never failed until at the command of the great Master-Workman the "wheels of life have stood still."‡

* Our common words, *hearty*, *large-hearted*, *courage* (*cor*, the heart), are remains of this fanciful theory.

† The greatest exploit ever accomplished by a locomotive, was to lift itself through less than one-eighth of that distance. Vast and constant as is this process, so perfect in the machinery that there are persons who do not even know where the heart lies until disease or accident reveals its location.

‡ "Our brains are seventy-year clocks. The Angel of Life winds them up once for all, then closes the case, and gives the key into the hand of the Angel of the Resurrection. Tic-tac! tic-tac! go the wheels of thought; our will cannot stop them, they cannot stop themselves; sleep cannot stop them; madness only makes them go faster; death alone can break into the case, and, seizing the ever-swinging pendulum, which we call the heart, silence at last the clicking of the terrible escapement we have carried so long beneath our wrinkled fore-heads."—HOLMES.

Fig. 43.

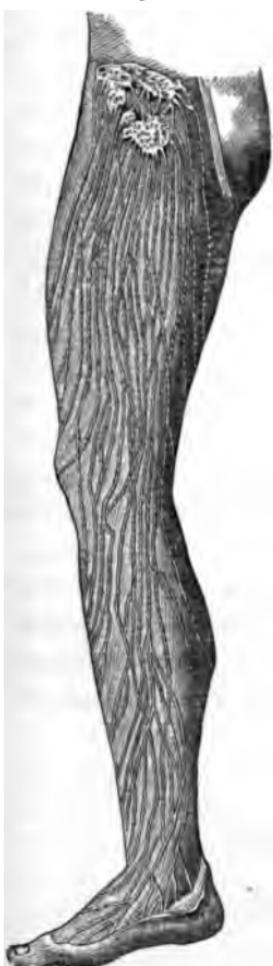


Lymphatics of the head and neck, showing the glands, and, B, the thoracic duct as it empties into the left innominate vein at the junction of the left jugular and subclavian veins.

The Lymphatic Circulation is intimately connected with that of the blood. It is, however, more delicate in its organization, and less thoroughly understood. Nearly every part of the body is permeated by a second series of capillaries, closely interlaced with the blood capillaries already described, and termed the Lymphatic system. The larger number converge into the thoracic duct—a small tube, about the size of a goose-quill, which empties into the great veins of the neck. (Fig. 43.). Along their course the lymphatics frequently pass through *glands*—hard, pinkish bodies of all sizes, from that of a hemp-seed to an almond. These glands are often enlarged by disease, and then are easily felt.

The Lymph, which circulates through the lymphatics like blood through the veins, is a thin, colorless liquid, very like the serum. This fluid, probably in great meas-

FIG. 44.



Lymphatics in the leg, with glands at the hip.

ure an overflow from the blood-vessels, is gathered up by the lymphatics, undergoes in the glands some process of preparation not well understood, and is then returned to the circulation.

Office of the Lymphatics.—It is thought that portions of the waste matter of the body capable of further use are thus, by a wise economy, retained and elaborated in the system. The *lacteals*, a class of lymphatics which will be described hereafter, take up the food from the digestive organs and fit it for the use of the blood. In the lungs the lymphatics are abundant, absorbing the poison of disease, and diffusing it through the system.* The lymphatics of the skin we have already spoken of as producing the phenomena of absorption.† Nature in her effort to heal a cut deposits an excess of matter to fill up the breach. Soon the lymphatics go to work and remove the surplus material to other parts of the body. Animals which

* Persons have thus been poisoned by tiny particles of arsenic which evaporate from green wall-paper, and float in the air.

† Pain is often relieved by infusing under the cuticle a solution of morphine, which is taken up by the absorbents, and so carried through the system.

hibernate are supported during the winter by the fat which their absorbents carry into the circulation from the extra supply they have laid up during the summer. In famine or in sickness a man unconsciously consumes his own flesh.

Diseases, etc.—1. *Congestion* is an unnatural accumulation of blood in any part of the body. The excess is indicated by the redness. If we put our feet in hot water, the capillaries will expand by the heat, and the blood set that way to fill them. The red nose and purplish face of the drunkard show a congestion of the capillaries. Those vessels have lost their power of contraction, and so are permanently increased in size and filled with blood. Blushing is a temporary congestion. The capillaries being expanded only for an instant by the nervous excitement, contract again and expel the blood.*

* “*Blushing* is a purely local modification of the circulation of this kind, and it will be instructive to consider how a blush is brought about. An emotion—sometimes pleasurable, sometimes painful—takes possession of the mind: thereupon a hot flush is felt, the skin grows red, and according to the intensity of the emotion these changes are confined to the cheeks only, or extend to the ‘roots of the hair,’ or ‘all over.’ What is the cause of these changes? The blood is a red and a hot fluid; the skin reddens and grows hot, because its vessels contain an increased quantity of this red and hot fluid; and its vessels contain more, because the small arteries suddenly dilate, the natural moderate contraction of their muscles being superseded by a state of relaxation. In other words, the action of the nerves which cause this muscular contraction is suspended.

“On the other hand, in many people, extreme terror causes the skin to grow cold, and the face to appear pale and pinched. Under these circumstances, in fact, the supply of blood to the skin is greatly diminished, in consequence of an excessive stimulation of the nerves of the small arteries, which causes them to contract and so to cut off the supply of blood more or less completely.

“That this is the real state of the case may be proved experimentally upon rabbits. These animals, it is true, do not blush naturally, but they may be made to blush artificially. If, in a rabbit, the sympathetic nerve which sends branches to the vessels of the head is cut, the ear of the rabbit, which is covered by so delicate an integument that the changes in its vessels can be readily perceived, at once blushes. That is to say, the vessels dilate, fill with blood, and the ear becomes red and hot. The reason of this is, that when the sympathetic nerve is cut, the nervous stimulus which is ordinarily sent along its branches is inter-

2. *Inflammation* means simply a burning. If there is irritation or an injury at any spot, the blood sets thither and reddens it. This extra supply, both by its presence and the friction of the swiftly moving currents, produces heat. The pressure of the distended vessels upon the nerves frets them, and produces pain. The swelling stretches the walls of the blood-vessels, and the serum or lymph oozes through. The four characteristics of an inflammation are redness, heat, pain, and swelling.

3. *Bleeding*, if from an artery, will be of red blood, and will come in jets; if from the veins, it will be of dark blood, and will flow in a steady stream. If only a small vessel be severed, it may be checked by a piece of cloth held or bound firmly upon the wound. If a large trunk be cut, especially in a limb, make a knot in a handkerchief and tie it loosely about the limb; then, placing the knot on the wound, with a short stick twist the handkerchief tightly enough to stop the flow.* If you have a piece of cloth to use as a pad, the knot will be unnecessary. If you are alone, and are severely wounded, or in an emergency, like a railroad accident, use the remedy which has saved many a life upon the battle-field; bind or hold a handful of dry earth upon the wound, elevate the part, and await surgical assistance.

ruptured, and the muscles of the small vessels, which were slightly contracted, become altogether relaxed.

"And now it is quite possible to produce pallor and cold in the rabbit's ear. To do this it is only necessary to irritate the cut end of the sympathetic nerve which remains connected with the vessels. The nerve then becomes excited, so that the muscular fibres of the vessels are thrown into a violent state of contraction, which diminishes their calibre so much that the blood can hardly make its way through them. Consequently, the ear becomes pale and cold."—HUXLEY'S *Lessons in Physiology*, page 58.

* It will, of course, be remembered that if it be an artery which is cut, the pressure should be applied between the wound and the heart; if a vein, beyond the wound.

4. *Scrofula* is generally inherited. It is a disease affecting the lymphatic glands, most commonly those of the neck, forming "kernels," as they are called. It is, however, liable to attack any organ, and frequently terminates in consumption. Persons inheriting this disease can hope to ward off its insidious approaches only by the utmost care in diet, exercise, and by the use of pure air and warm clothing, avoiding late hours and undue stimulus of all kinds. Probably the most fatal and common excitants of the latent seeds of scrofula are insufficient or improper food and want of ventilation.

5. *A Cold*.—We put on a thinner dress than usual, or, when heated, sit in a cool place. The skin is chilled, and the perspiration checked. The blood, no longer cleansed, and reduced in volume by the drainage through the pores, sets to the lungs for purification. That organ is oppressed, breathing becomes difficult, and the extra mucus secreted by the irritated surface of the membrane is thrown off by coughing. The mucous membrane of the nasal chamber sympathizes with the difficulty, and we have "a cold in the head," or a catarrh. In general, the excess of blood seeks the weakest point, and develops there any latent disease.* Where one person has been killed in battle, thousands have died of colds.

To restore the equipoise must be the object of all treatment. We put the feet in hot water and they soon become red and gorged with the blood which is thus called

* A party go out for a walk and are caught in a rain, or coming home heated from some close assembly, throw off their coats to enjoy the deliciously cool breeze. The next day one has a fever, another a slight headache, another pleurisy, another pneumonia, another rheumatism, while some escape without any ill feeling whatever. The last had vital force sufficient to withstand the disturbance, but in the others there were weak points, and to these the excess of blood has gone, producing congestion.

from the congested organs. Hot foot-baths have saved multitudes of lives. It is well in case of a sudden cold to go immediately to bed, and with hot drinks and extra clothing open the pores, and induce free perspiration. This calls the blood to the surface, and by equalizing and at the same time diminishing the volume of the circulation, affords relief.*

The rule for prevention and cure of a cold is to *keep the blood upon the surface.*

6. *Catarrh* most commonly manifests itself by the symptoms known as those of a "cold in the head," and is produced by the same causes. It is an inflammation of the mucous membrane lining the nasal and bronchial passages. One going out from the hot dry air of a furnace-heated room into the cold damp atmosphere of our climate can hardly avoid irritating and inflaming this tender membrane. If our rooms were heated less intensely, and ventilated more thoroughly, so that we had not the present hot-house sensitiveness to cold air, this disease would be far less universal, and perhaps would disappear entirely.†

* Severe colds may often be relieved in their first stages by using lemons freely during the day, and taking at night fifteen or twenty grains of potassium bromide.

† Dr. Gray gives the following table based upon measurement of rooms occupied by letter-press printers:

	Number per cent. Splitting Blood.	Subject to Catarrh.
104 men having less than 500 cubic feet of air to breathe	12.50	12.50
115 men having from 500 to 600 cubic feet of air to breathe	4.85	3.48
101 men having more than 600 cubic feet of air to breathe	3.96	1.98

PRACTICAL QUESTIONS.

1. Why does a dry, cold atmosphere favorably affect catarrh ?
2. Why should we put on extra covering when we lie down to sleep ?
3. Is it well to throw off our coats or shawls when we come in heated from a long walk ?
4. Why are close-fitting collars or neck-ties injurious ?
5. Which side of the heart is the more liable to inflammation ?
6. What gives the toper his red nose ?
7. Why does not the arm die when the surgeon ties the principal artery leading to it ?
8. When a fowl is angry, why does its comb redden ?
9. Why does a fat man endure cold better than a lean one ?
10. Why does one become thin during a long sickness ?
11. What would you do if you should come home "wet to the skin ?"
12. When the cold air strikes the face, why does it first blanch and then flush ?
13. What must be the effect of tight lacing upon the circulation of the blood ?
14. Do you know the position of the large arteries in the limbs, so that in case of accident you could stop the flow of blood ?
15. When a person is said to be "good-hearted," is it a physical truth ?
16. Why does a hot foot-bath relieve the headache ?
17. Why does the body of a drowned or strangled person turn blue ?
18. What are the little "kernels" in the arm-pits ?
19. When we are excessively warm, would the thermometer show any rise of temperature in the body ?
20. What forces besides that of the heart aid in propelling the blood ?
21. Why can the pulse be felt best in the wrist ?
22. Why are starving people exceedingly sensitive to any jar ?
23. Why will friction, an application of horse-radish leaves, or a blister relieve internal congestion ?
24. Why are students very liable to cold feet ?
25. Is the proverb that "blood is thicker than water" literally true ?
26. What is the effect upon the circulation of "holding the breath ?"

27. Which side of the heart is the stronger ?
28. How is the heart itself nourished ?*
29. Does any venous blood reach the heart without coming through the vena cava ?

* The coronary artery, springing from the aorta just after its origin, carries blood to the muscular walls of the heart: the venous blood comes back through the coronary veins, and empties directly into the right auricle.

VI.

DIGESTION AND FOOD.

A MAN puts some ashes in a hill of corn and thereby doubles its yield. Then he says, "My ashes have I turned into corn." Weak from his labor, he eats of his corn, and new life comes to him. Again, he says, "I have changed my corn into a man." This also he feels to be the truth.

It is the problem of the body, remember, that we are discussing. A man is more than the body; to confound the body and the man is worse than confounding the body and the clothing.—JOHN DARBY.



D I G E S T I O N

A N D

F O O D.

WHY we need Food.—We have learned that our bodies are constantly giving off waste matter—the products of the fire or oxidation, as the chemist terms it, going on within us. If fresh fuel be not supplied, the fire will soon go out. A man without food will starve to death in a few days, i. e., the oxygen will have consumed all the available flesh of his body.* To replace the daily outgo we need about two and a quarter pounds of food, and three pounds of drink. (See Appendix, p. 220.)

With the eight hundred pounds of oxygen taken from the air, a man uses in a year about a ton and a half of

* The stories current in the newspapers of persons who live for years without food are, of course, untrue. The recent case of the Welsh Fasting Girl, which excited general interest throughout Great Britain, and was extensively copied in our own press, is in point. She had succeeded in deceiving not only the public but, as some claim, her own parents. At last a strict watch was set by day and night, precluding the possibility of her receiving any food except at the hands of the committee, from whom she steadily refused it. In a few days she died from actual starvation. The youth of the girl, the apparent honesty of the parents, and the tragical sequel, make it one of the most remarkable cases of the kind on record.

material.* Yet during this entire time his weight may be nearly uniform.† Our bodies are but moulds, in which a certain quantity of matter, checked for a time on its ceaseless round, receives a definite form. They may be likened, says Huxley, to an eddy in the river, which retains its shape for a while, yet every instant each particle of water is changing.

What Food Does.—We make no force ourselves. We can only use that which nature provides.‡ All our strength comes from the food we eat. Food is force—that is, it contains latent within it a power which it gives up when it is decomposed.§ Oxygen is the magic key

* The following is the daily ration of a United States soldier. It is said to be the most generous in the world:—

Bread or flour,	22	ounces.
Fresh or salt beef (or pork or bacon, 12 oz.),	20	"
Potatoes (three times per week),	16	"
Rice,	1·6	"
Coffee (or tea, 0·24 oz.),	1·6	"
Sugar,	2·4	"
Beans,	0·64	gill.
Vinegar,	0·32	"
Salt	0·16	"

† If, however, he were kept on the scale-pan of a sensitive balance, he would find that his weight is constantly changing, increasing with each meal, and then gradually decreasing.

‡ We draw from nature at once our substance, and the force by which we operate upon her; being, so far, parts of her great system, immersed in it for a short time and to a small extent. Enfolding us, as it were, within her arms, Nature lends us her forces to expend; we receive them, and pass them on, giving them the impress of our will, and bending them to our designs, for a little while; and then—Yes; then it is all one. The great procession pauses not, nor flags a moment, for our fall. The powers which Nature lent to us she resumes to herself, or lends, it may be, to another: the use which we have made of them, or might have made and did not, written in her book for ever.—*Health and its Conditions.*

§ This force is chemical affinity. It binds together the molecules which compose the food we eat. When oxygen tears the molecules to pieces and makes them up into smaller ones the force is set free. As we shall learn in Philosophy, it can be turned into heat, muscular motion, electricity, etc. The principle that the different kinds of force can be changed into one another without loss, is called the Conservation of energy, and is one of the grandest discoveries of modern science. (See Physics, pages, 37, 40, 206.)

which unlocks for our use this hidden store. Putting food into our bodies is like placing a tense spring within a watch ; every motion of the body is only a new direction given to this food-force, as every movement of the hand on the dial is but the manifestation of the power of the bent spring in the watch. We use the pent-up energies of meat, bread, and vegetables which are placed at our service, and transfer them to a higher theatre of action.*

Kinds of Food Needed.—From what has been said it is clear that, in order to produce heat and force, we need something that will burn, i. e., with which oxygen can combine. Experiment has proved that to build up every organ, and keep the body in the best condition, we require three kinds of food.

1. *Nitrogenous Food*, or that which contains much nitrogen. This is a prominent constituent of the tissues of the body, and is therefore necessary to their growth and repair.† The most common forms are whites of eggs—which are nearly pure albumen ; caseine—the chief constituent of cheese ; lean meat ; and gluten—the viscid substance which gives tenacity to dough. Bodies having a great deal of nitrogen readily oxidize. Hence the peculiar character of the quick-changing, force-exciting muscle.

2. *Carbonaceous Food*—i. e., food containing much carbon. This consists of two kinds—viz., the *sugars* and the *fats*.

(1.) *The sugars* contain hydrogen and oxygen in the

* It is a grand thought that we can thus transform what is common and gross into the refined and spiritual—that out of waving wheat, wasting flesh, running water, and dead minerals, we can realize the glorious possibilities of human life.

† Since this kind of food closely resembles albumen, it is sometimes called *Albuminous*.

proportion to form water, and about the same amount of carbon. They may, therefore, be considered as water, with carbon diffused through it. In digestion, starch and gum are changed to sugar, and so are ranked with this class.

(2.) *The fats* are like the sugars in composition, but contain less oxygen, and not in the proportion to form water. They combine with more oxygen in burning, and so give off more heat.

The non-nitrogenous elements of the food have, however, other uses than to develop heat.* Fat is essential to the formation of every organ, and to the assimilation of the food, while sugar and starch aid in digestion, and may be converted into fat.†

3. *Mineral Matters.*—Food should contain water and certain common minerals, such as iron,‡ sulphur, magnesia, phosphorus, salt, and potash. About three pints of water are needed daily to dissolve the food and carry it through the circulation, to float off waste matter, to lubricate the tissues, and by evaporation to cool the system. It also enters largely into the composition of the body. A man weighing 154 pounds contains 100 pounds of water, about 12 gallons—enough, if rightly arranged, to drown him. §

* The heat they produce in burning may be turned into motion of the muscles, according to the principle of the Conservation of energy. (See p. 134, note.) While all the structures of the body in their oxidation develop heat.

† In Turkey the ladies of the harem are fed on honey and thick gruel to make flesh, which is considered to enhance their beauty.—The negroes on the sugar plantations of the South always grow fat during the sugar-making season.

‡ While the body can build up a solid from liquid materials on the one hand, on the other it can pour iron through its veins and reduce the hardest textures to blood.—HINTON.

§ It is said that Blumenbach had a perfect mummy of an adult Tenerifian, which with the viscera weighed only seven and a half pounds.

Iron goes to the blood disks; lime combines with phosphoric and carbonic acid to give solidity to the bones and teeth; phosphorus is essential to the activity of the brain. Salt is necessary to the secretion of some of the digestive fluids, and also to aid in working off from the system its waste products. These various minerals, except iron, which is sometimes given as a medicine, and salt, universally used as a condiment,* are contained in small, but sufficient quantities in meat, bread, and vegetables.

One Kind of Food is Insufficient.—A person fed on starch alone, having nothing with which to make muscle, would die. It would be a clear case of nitrogen starvation. On the other hand, as nitrogenous food contains carbon, the elements of water, and various mineral matters, life could be supported on that alone. But such a prodigious quantity of lean meat, for example, would be required to furnish the other elements, that not only

* "Animals will travel long distances to obtain salt. Men will barter gold for it; indeed, among the Gallas and on the coast of Sierra Leone, brothers will sell their sisters, husbands their wives, and parents their children for salt. In the district of Accra, on the gold coast of Africa, a handful of salt is the most valuable thing upon earth after gold, and will purchase a slave or two. Mungo Park tells us that with the Mandingoës and Bambaras the use of salt is such a luxury that to say of a man, 'he flavors his food with salt,' it is to imply that he is rich; and children will suck a piece of rock-salt as if it were sugar. No stronger mark of respect or affection can be shown in Muscovy, than the sending of salt from the tables of the rich to their poorer friends. In the book of Leviticus it is expressly commanded as one of the ordinances of Moses, that every oblation of meat upon the altar shall be seasoned with salt, without lacking; and hence it is called the Salt of the Covenant of God. The Greeks and Romans also used salt in their sacrificial cakes; and it is still used in the services of the Latin church—the '*parva mica*,' or pinch of salt, being, in the ceremony of baptism, put into the child's mouth, while the priest says, 'Receive the salt of wisdom, and may it be a propitiation to thee for eternal life.' Everywhere, and almost always, indeed, it has been regarded as emblematical of wisdom, wit, and immortality. To taste a man's salt, was to be bound by the rites of hospitality; and no oath was more solemn than that which was sworn upon bread and salt. To sprinkle the meat with salt was to drive away the devil, and to this day, nothing is more unlucky than to spill the salt."—LETHEBY, *On Food*.

would it be very expensive, but it is likely that after a time the labor of digestion would be too onerous, and the system would give up the task in despair. The need of a diet containing both nitrogenous and carbonaceous elements is shown in the fact that even in the tropical regions oil is relished as a dressing upon salad. Instinct everywhere suggests the blending. Butter is used with bread; rice is boiled with milk; cheese is eaten with maccaroni, and beans are baked with pork.

The Object of Digestion.—If our food were cast directly into the blood, it could not be used. For example, although the chemist cannot see wherein the albumen of the egg differs from the albumen of the blood, yet if it be injected into the veins it is unavailable for the purposes required, and is thrown out again. In the course of digestion the food is modified in various ways whereby it is fitted for the use of the body. We call this process *assimilation*—a name for a work done only by the vital organs, and so mysterious in its nature that the wisest physiologist only gets glimpses here and there of its operations.

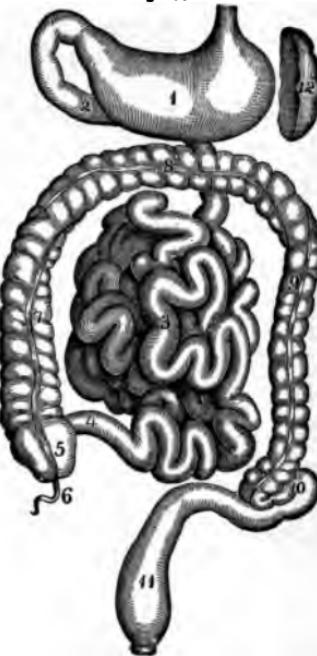
The General Plan of Digestion.—Nature has provided for this purpose an entire laboratory, completely furnished with a chemist's outfit of knives, mortars, baths, chemicals, filters, etc. The food is (1) chewed, mixed with the saliva in the mouth, and swallowed; (2) it is acted upon by the gastric juice in the stomach; (3) passed into the intestines, where it receives the bile, pancreatic juice, and other liquids which completely dissolve it;*

* "Digestion," says Berzelius, "is a process of rinsing." The digestive apparatus secretes, and again absorbs with the food which it has dissolved, not less than three gallons of liquid per day.—BARNARD, BIDDER, SCHMIDT, and others.

(4) the nourishing part is absorbed in the stomach and intestines, and thence thrown into the blood-vessels, whence it is whirled through the body by the torrent of the circulation. These processes take place within the *alimentary canal*, as it is called—a narrow, tortuous tube which commences at the mouth, and is about thirty feet long.*

I. Mastication and Insalivation.—1. *The Saliva.*—The food while being cut and ground by the teeth is mixed with the saliva. This is a thin, colorless, frothy, slightly alkaline liquid, secreted† by the mucous membrane lining the mouth, and by three pairs of salivary glands (parotid, submaxillary, and sublingual,) opening into the mouth through

Fig. 44.



The Stomach and Intestines. 1, stomach; 2, duodenum; 3, small intestine; 4, termination of the ileum; 5, cecum; 6, vermiform appendix; 7, ascending colon; 8, transverse colon; 9, descending colon; 10, sigmoid flexure of the colon; 11, rectum; 12, spleen—a gland whose action is not understood.

* The digestive apparatus is lined with mucous membrane, which possesses functions similar to those of the outer skin. It absorbs certain substances and rejects waste matter. On account of this close connection between the inner and outer skin, it is not surprising to find that in the lowest animals digestion is performed by means of the external skin. The amœba, which is merely a gelatinous mass, when it takes its food extemporizes a stomach for the occasion. It simply wraps itself around the morsel, and like an animated apple-dumpling with the apple for food and the crust for animal, goes on with the process until the operation is completed, when it unrolls itself again and lets the indigestible residue escape. The common hydra of our brooks also does just as well when turned inside out, like a glove: either side serves equally for skin or stomach.

† By secretion is meant merely a separation or picking out from the blood.

FIG. 15.



The Parotid—one of the salivary glands.

ducts, or tubes. The amount varies, but on the average is about three pounds per day, and in health is always sufficient to keep the mouth moist.* It softens and dissolves the food, and thus enables us to get the flavor or taste of what we eat. It contains a peculiar organic principle called *ptyalin*,† which, acting upon the starch of the food, changes it into a kind of sugar.

2. *The Process of Swallowing.*—The food thus finely pulverized, softened, and so lubricated by the viscid saliva as to prevent all friction as it passes over the delicate membranes, is conveyed by the tongue and cheek to

* The presence and often the thought of food will "make one's mouth water." Fear checks the flow of saliva, and hence the East Indians sometimes attempt to detect theft by making those who are suspected chew rice. The person from whom it comes out driest is adjudged the thief!

† One part of ptyalin will convert 8,000 parts of starch into sugar.—MIALHE.

The saliva has no chemical action on the fats or the albuminous bodies. Its frothiness enables it to carry oxygen into the stomach, and this is thought to be of service. The action of the ptyalin commences with great promptness, and sugar has been detected, it is said, within half a minute after the starch was placed in the mouth. The process, however, is not finished there, but continues after reaching the stomach.—VALENTIN.

The saliva thus prepares a small portion of food for absorption at once, and so ensures at the very beginning of the operation of digestion a supply of force-producing material for the immediate use of the system.

the back of the mouth. The soft palate is lifted so as to close the nasal opening; the epiglottis shuts down, and along this bridge the food is borne, without danger of falling into the windpipe or escaping into the nose. The muscular bands of the throat now seize it and take it beyond our control. The fibres of the œsophagus contract above, while they are lax below, and convey the food by a worm-like motion into the stomach.*

II. Gastric Digestion.—1. *The Stomach* is an irregular expansion of the digestive tube. Its shape has been compared to that of a bagpipe. It holds about three pints, though it is susceptible of some distension. It is composed of an inner mucous membrane, which secretes the digestive fluids; an outer, smooth, well-lubricated serous one, which prevents friction, and between them a stout, muscular coat. The last consists of two layers of longitudinal and circular fibres. When these contract, they produce a peculiar churning motion, called the *peristaltic* (*peri*, round; *stallein*, to arrange) movement, which thoroughly mixes the contents of the stomach. At the further end, the muscular fibres contracting form a gateway, the *pylorus* (a gate), as it is called, which carefully guards the exit, and allows no food to pass from the stomach until properly prepared.†

2. *The Gastric Juice*.—The lining of the stomach is soft, velvety, and of a pinkish hue; but as soon as food is admitted, the blood-vessels fill, the surface becomes of a bright red, and soon there exudes from the gastric glands

* We can observe the peculiar motion of the œsophagus by watching a horse's neck when he is drinking.

† With a wise discretion, however, it opens for buttons, coins, etc., swallowed by accident, and when we overload the stomach it seems to become weary of constantly denying egress, and, giving up in despair, lets everything through.

a thin, colorless fluid—the *gastric juice*. This is secreted to the amount of twelve pounds per day.* Its acidity is probably due to muriatic or lactic acid—the acid of sour milk. It contains a peculiar organic principle called *pepsin*† (*pepto*, to digest), which acts as a ferment to produce changes in the food, without being itself modified. The flow of *gastric juice* is influenced by various circumstances. Cold water checks it for a time, and ice for a longer period. Anger, fatigue, and anxiety delay and even suspend the secretion. The *gastric juice* has but slight effect on the fats or the sugars of the food; its influence being mainly confined to the albuminous bodies, which it so changes that they become soluble in water.‡

The food, reduced by the action of the *gastric juice* to a grayish, soupy mass, called *chyme* (kime), escapes through that jealously guarded door, the *pylorus*.

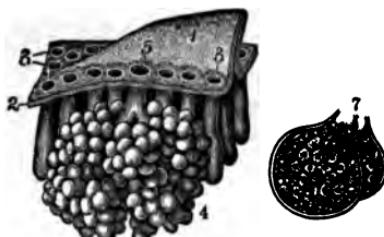
III. Intestinal Digestion.—The structure of the intestines is like that of the stomach. There is the same smooth, outer, serous membrane to prevent friction, the lining of mucous membrane to secrete the digestive fluids, and the muscular coating to push the food forward. The intestines are divided into the *small* and the *large*. The

* The amount secreted by a healthy adult is variously estimated from five to thirty-seven pounds. As it is re-absorbed by the blood, there is no loss.

† Pepsin is prepared and sold as an article of commerce. The best is said to be made from the stomachs of young, healthy pigs, which, just before being killed, are excited with savory food, which they are not allowed to eat. One grain is sufficient to dissolve 800 grains of coagulated whites of eggs. A temperature of 130° renders pepsin inert.

‡ The question is often asked why the stomach itself is not digested by the *gastric juice*, since it belongs to the albuminous substances. Some assign as the reason that life protects that organ, and that living tissues cannot be digested. The fallacy of this has been clearly shown by introducing the legs of live frogs and the ears of rabbits through an opening made in a dog's stomach, where they were readily digested. The latest opinion is that the blood which circulates so freely through the vessels of the lining of the stomach, being alkaline, protects the tissue against the acidity of the *gastric juice*.

FIG. 16.



A Vertical Section of the Duodenum, highly magnified. 1, a fold-like villus; 2, epithelium, or cuticle; 3, orifices of intestinal glands; 5, orifice of duodenal glands, 4; 7, more highly magnified section of the cells of a duodenal gland.

first part of the former opens out of the stomach, and is called the *du-o-de'-num*, as its length is equal to the breadth of twelve fingers. Here the chyme is acted upon by the *bile* and the *pancreatic juice*.

1. *The Bile* is secreted by the liver.* This gland weighs about four pounds, and is the largest in the body. It is located on the right side, below the diaphragm. The bile is of a dark, golden color and bitter taste. About three pounds are secreted per day. When not needed for digestion, it is stored in the gall cyst.† Its action on the food, though not understood, is necessary to life.‡

2. *The Pancreatic Juice* is a secretion of the pancreas, or "sweet-bread"—a gland nearly as large as the hand, lying behind the stomach. It is slightly alkaline,

* The liver not only forms the bile out of the blood, but elaborates from it what is called liver-sugar, and probably also colorless corpuscles: both these substances being found in the blood more plentifully after it has passed through this organ.

† A gall-bladder can be obtained from a butcher, and the contents kept in a bottle for examination.

‡ Experiments have been made with animals by opening the gall-bladder and allowing the gall as secreted to flow out of the body without entering the stomach. FLINT describes a case where a dog was thus treated. Although plentifully fed, he died in thirty-eight days. He suffered no pain, and death came gradually, merely through a failure of the vital powers.

pared with the simplicity of respiration and circulation, is very marked. The mechanical operation of mastication; the lubrication of the food by mucus; the provision for the security of the respiratory organs; the grasping by the muscles of the throat; the churning movement of the stomach; the guardianship of the pylorus; the timely introduction by safe and protected channels of the saliva, the gastric juice, the bile, the pancreatic juice, and the intestinal fluids, each with its special adaptation; the curious peristaltic motion of the intestines; the twofold absorption by the veins and the lacteals; the final transformation in the lymphatics, the portal vein, and the liver,—all these present a complexity of detail, the necessity of which can only be explained when we reflect upon the variety of the substances we use for food, and the importance of its thorough preparation before it is allowed to enter the blood.

The Length of Time Required for digesting a full meal is from two to four hours. It varies with the kind of food, state of the system, perfection of mastication, etc. In the celebrated observations made upon Alexis St. Martin* by Dr. Beaumont, his stomach was found empty in two and a half hours after a meal of roast turkey, potatoes, and bread. Pigs' feet and boiled rice were disposed

* In 1822, Alexis St. Martin, a Canadian in the employ of the American Fur Company, was accidentally shot in the left side. Two years after, the wound was entirely healed, leaving, however, an opening about two and a half inches in circumference into the stomach. Through this the mucous membrane protruded, forming a kind of valve which prevented the discharge of food but could be readily depressed by the finger, thus exposing the interior. For several years he was under the care of Dr. Beaumont, a skilful physician, who experimented upon him by giving various kinds of food, and watching their digestion through this opening. By means of these observations, and others performed on Katherine Kutt, a woman who had a similar aperture in the stomach, we have very important information as to the digestibility of different kinds of food.

of in an hour. Fresh, sweet apples took one and a half hours; boiled milk, two hours; and unboiled, a quarter of an hour longer. In eggs, which occupied the same time, the case was reversed—raw ones being digested sooner than cooked. Roast beef and mutton required three, and three and a quarter hours respectively; veal, salt beef, and broiled chicken remained for four hours; and roast pork enjoyed the bad pre-eminence of needing five and a quarter.

Value of the Different Kinds of Food.—*Beef* and ***Mutton*** possess the greatest nutritive value of any of the meats. ***Lamb*** is less strengthening, but more delicate. Like the young of all animals, it should be thoroughly cooked, and at a high temperature, properly to develop its delicious flavor. ***Pork*** has much carbon, and is hence very heating. Those who work in the open air can dispose of it easily, but the sedentary have little need of such food. It sometimes contains a parasite called trichina, which may be transferred to the human system, producing disease and often death. The only preventive is thorough cooking. ***Fish*** is more watery than flesh, but is very like it in composition. Many, however, find it difficult of digestion. Like meat, it loses its mineral constituents and natural juices when salted, and is much less nourishing. Oysters are highly nutritious, but are more easily assimilated when raw than when cooked. ***Milk*** is a model food, as it contains albumen, starch, fat, and mineral matter. No single substance can sustain life for so long a time. ***Cheese*** is very nourishing—one pound being equal in value to two of meat, but is not adapted to a weak stomach. ***Eggs*** are most easily digested when the white is barely coagulated and

the yolk is unchanged. *Bread** should be made of unbolted flour. The bran of wheat furnishes the mineral matter we need in our bones and teeth, gives the bulk so essential to the proper distention of the organs, and by its roughness gently stimulates them to action. *Corn* is rich in fat. It contains, however, more indigestible matter than any other grain, except oats, and is less nutritious than wheat.† The *Potato* is two-thirds water—the rest being mainly starch. *Ripe Fruits*, and those vegetables usually eaten raw, dilute the more concentrated food, and also supply the blood with acids, which are cooling in summer, and useful, perhaps, in assimilation.

The Stimulants.—*Coffee* is about half nitrogen, and the rest fatty, saccharine, and mineral substances. It is, therefore, of much nutritive value, especially when taken with milk and sugar. Its peculiar stimulating property is due to a principle called *caffeine*. Its aroma is developed by browning, but destroyed by burning. No other substance so soon relieves the sense of fatigue.‡ Taken in

* Very fresh bread, warm biscuit, etc., are condensed by mastication into a pasty mass which is not easily penetrated by the gastric juice, and hence they are not healthful. In Germany, bread is not allowed to be sold at the baker's till it is twenty-four hours old—a wise provision for those who have not strength to resist temptation. This rule of eating may well be adopted by every one who cares more for his health than for a gratification of his appetite.

† Persons unaccustomed to the use of corn find it liable to produce derangement of the digestive organs. This was made fearfully apparent in the prisons at Andersonville during the late civil war. The vegetable food of the Federal prisoners had hitherto been chiefly wheat-bread and potatoes—the corn bread so extensively used at the South being quite new to most of them as a constant article of diet. It soon became not only loathsome, but productive of the most serious diseases. On the other hand, it was the principal article in the rations of the Confederate soldiers, to whom habit made it a nutritious and wholesome form of food, as was shown by their endurance. (See FLINT's *Physiology of Man*, vol. 2, page 41.)

‡ In the late civil war, the first desire of the soldiers upon halting after a wearisome march, was to make a cup of coffee. This was taken without milk, and often without sugar, yet was always welcome. During Kane's travels in

moderation, it clears the intellect, tranquillizes the nerves, and usually leaves no unpleasant reaction. It serves also as a kind of negative food, since it retards the process of waste.

In some cases, however, it produces a rush of blood to the head, and should be at once discarded. At the close of a full meal it hinders digestion, and at night produces wakefulness. In youth, when the vital powers are strong, and the elasticity of nature prompt in rallying from fatigue, it is not needed, and may be injurious in stimulating a sensitive organization.

Tea possesses an active principle called *theine*. When used moderately, its effects are similar to those of coffee, except that it exerts an astringent action. It contains tannin, which, if the tea is strong, coagulates the albumen of the food—actually *tans* it—and thus delays digestion.*

Chocolate contains much fat, and also nitrogenous matter resembling albumen. Its active principle, *theobromine*,† has some of the properties of caffeine and theine.

Tobacco contains an active principle called *nicotine*. This is so virulent a poison that the amount in one or two cigars, if thrown directly into the circulation, would cause death. When tobacco is burned, the nicotine enters the smoke, and is to some extent absorbed. Its effects vary with the habits, constitution, etc., of the individual. In many adults it seems to have no injurious influence,

the Arctic regions, he found "both tea and coffee to act like a charm, and to be decidedly superior to alcoholic stimulants."

* Tea and coffee should be made with boiling water, but should not be boiled afterward. During the "steeping" process, so customary in this country, the volatile aroma is lost and a bitter principle extracted. In both England and China it is usual to infuse tea directly in the urn from which it is to be drawn.

† It is said that Linnæus, the great botanist, was so fond of chocolate that he named the cocoa-tree "Theobroma," the food of the gods.

yet it rarely, if ever, does any special good, and all would undoubtedly be better without it. Even when the system seems to endure the nicotine, symptoms of chronic poisoning often appear after a time.

Tobacco is always detrimental to youth, especially those of a nervous, sensitive organization. Its tendency is to retard the development of the body. It will, therefore, diminish the mental force with which a young man commences the work of life,* while its narcotic influence will often beguile his energy and palsy his strength at the very time when every faculty should be awake.

Alcohol is the active principle of all fermented liquors. Like tobacco, it checks the waste of the body, and so acts as a negative food. Contrary to the commonly received opinion, it does not fortify against cold. It is a powerful stimulant, and often sustains the vital energies when at a low ebb, as in sickness, or spurs them when flagging, as in old age. It is, therefore, a valuable remedy. So subtle and dangerous, however, is its influence on the body (see p. 172), and so great is its liability to abuse, that it should rarely be taken except under competent medical advice. The indiscriminate use of intoxicating liquors, both as a medicine and a beverage, is the curse of society.

The Cooking of Food breaks the little cells and softens the fibres of which it is composed. In broiling or roasting meat, it should be exposed to a strong heat at once, in order to coagulate the albumen upon the outside, and thus prevent the escape of the nutritious juices. The

* In the Polytechnic school at Paris, the pupils were divided into two classes—the smokers and the non-smokers. The latter not only excelled on the entrance examinations, but during the entire course of study. Dr. Decaisne examined thirty-eight boys who smoked, and found twenty-seven of them diseased from the use of this poisonous substance.

cooking may then be finished at a lower temperature. The same principle applies to boiling meat. In making soups, on the contrary, the heat should be applied slowly, and should reach the boiling point only for a few moments at the close. This prevents the coagulation of the albumen. Frying is an unhealthy mode of cooking food, as thereby the fat becomes partially disorganized.

Rapid Eating produces many evil results. 1. There is not enough saliva mixed with the food; 2. The coarse pieces resist the action of the digestive fluids; 3. The food is washed down with drinks which dilute the gastric juice, and hinder its work; 4. We do not appreciate the quantity we eat until the stomach is overloaded; 5. Failing to get the taste of our food, we think it insipid, and hence use condiments which over-stimulate the digestive organs. In these various ways the appetite is depraved, the stomach vexed, the system overworked, and the foundations of dyspepsia laid.*

The Quantity and Quality of Food required vary with the age and habits of each individual. The diet of a child † should be largely vegetable, and more abundant than that of an aged person. A sedentary occupation necessitates less food than an out-door life. One accustomed to manual labor, on entering school, should practice self-denial until his system becomes fitted to the new order of things. He should not, however, fall into the opposite error. We read of great men who have lived on bread and

* When one is compelled to eat in a hurry, as at a railway station, he would do well to confine himself principally to meat; and to dilute this concentrated food with fruit, crackers, etc., taken afterward more leisurely.

† In youth, repair exceeds waste, and hence the body grows rapidly, and the form is plump. In middle life repair and waste equal each other, and growth ceases. In old age waste exceeds repair, and hence the powers are enfeebled and the skin lies in wrinkles on the shrunken form.

water, and the conscientious student sometimes thinks that, to be great, he, too, must starve himself.* On the contrary, the greatest workers are the greatest eaters. A powerful engine needs a corresponding furnace. Only we should be careful not to use more fuel than is needed to run the machine.

The season should modify our diet. In winter we need highly carbonaceous food, plenty of meat, fat, etc.; but in summer we should temper the heat in our corporal stoves with fruits and vegetables.

The climate also has its necessities. The inhabitants of the frigid North have an almost insatiable longing for fat. Thus, in 1812, when the Allies entered Paris, the Cossacks drank all the oil from the lamps, and left the streets in darkness. In tropical regions, a low, unstimulating diet of fruits forms the chief dependence.†

When Food should be Taken.—On taking food, the blood sets at once to the alimentary canal, and the energies are fixed upon the proper performance of this work. We should not, therefore, undertake hard study, labor, or exercise directly after a hearty meal. We should give the stomach at least half an hour. He who toils with brain or muscle, and thus centres the blood in any particular organ, before eating, should allow time for the

* As Dr. Holland well remarks, the dispensation of saw-dust has passed away. If we desire a horse to win the race, we must give him plenty of oats.

† A natural appetite for a particular kind of food is an expression not only of desire but of fitness. Thus the craving of childhood for sugar indicates a need heat-making food. It is questionable how far it is proper to force or persuade one to eat that which he disrelishes, or his stomach loathes. Life within is linked with life without. Each organ requires its peculiar nutriment, and there is often a peculiar influence demanded of which we can have no notice except by natural instinct. Yet, as we are creatures of habit and impulse, we need common sense and good judgment to correct the too often wayward promptings of an artificial craving. (See page 292.)

circulation to become equalized. There should be an interval of four to five hours between our regular meals, and there should be no lunching between times. With young children, where the vital processes are more rapid, less time should intervene. Nothing should be eaten within two or three hours of retiring.

How Food should be Taken.—A good laugh is the best of sauces. The meal-time should be the happiest hour of the day. Care and grief are the bitterest foes of digestion. A cheerful face and a light heart are friends to long life, and nowhere do they serve us better than at the table. God designed that we should enjoy eating, and that, having stopped before satiety was reached, we should have the satisfaction always attendant on a good work well done.

Need of a Variety.—Careful investigations have shown that any one kind of food, however nutritious in itself, fails after a time to preserve the highest working power of the body. Our appetite palls when we confine our diet to a regular routine. Nature demands variety, and she has furnished the means of gratifying it.*

The Wonders of Digestion.—We can understand much of the process of digestion. We can look into the stomach and trace its various steps. Indeed, the chemist

* "She opens her hand, and pours forth to man the treasures of every land and every sea, because she would give to him a wide and vigorous life, participant of all variety. For him the cornfields wave their golden grain—wheat, rye, oats, maize, or rice, each different, but alike sufficing. Freely for him the palm, the date, the banana, the bread-fruit tree, the pine, spread out a harvest on the air; and pleasant apple, plum, or peach solicit his ready hand. Beneath his foot lie stored the starch of the potato, the gluten of the turnip, the sugar of the beet; while all the intermediate space is rich with juicy herbs.

"Nature bids him eat and be merry; adding to his feast the solid flesh of bird, and beast, and fish, prepared as victims for the sacrifice: firm muscle to make strong the arm of toil, in the industrious temperate zone; and massive ribs of fat to kindle inward fires for the sad dwellers under Arctic skies."—*Health and its Conditions.*—HINTOM.

can reproduce in his laboratory many of the operations; "a step further," as Fontenelle has said, "and he would surprise nature in the very act." Just here, when he seems so successful, he is compelled to pause. At the threshold of life the wisest physiologist reverently admires, wonders, and worships. How strange is this transformation of food to flesh! We make a meal of meat, vegetables, and drink. Ground by the teeth, mixed by the stomach, dissolved by the digestive fluids, it is swept through the body. Each organ, as it passes, snatches its particular food. Within the cells of the tissues* it is transformed into the soft, sensitive brain, or the hard, callous bone; into briny tears, or bland saliva, or acrid perspiration; bile for digestion, oil for the hair, nails for the fingers, and flesh for the cheek. Within us is an Almighty Architect, who superintends a thousand builders, which make in a way past all human comprehension, here a fibre of a muscle, there a filament of a nerve; here constructing a bone, there uniting a tendon—fashioning each with scrupulous care and unerring nicety.† So, without sound of builder or stroke of hammer, goes up, day by day, the body—the glorious temple of the soul.

Diseases, etc.—1. *Dyspepsia*, or indigestion of food, is generally caused by an over-taxing of the digestive organs. Too much food is used, and the entire system is burdened by the excess. Meals are taken at irregular

* As the body is composed of individual organs (see page 19), and each organ of separate tissues (see page 24), so each tissue is made up of minute cells. Each cell is a little world by itself, too small to be seen by the naked eye, but open to the microscope. It has its own form and constitution as much as a special organ in the body. It absorbs from the blood such food as suits its purposes. Moreover the number of cells in an organ is as constant as the number of organs. As the organs expand with the growth of the body, so the cells of each tissue enlarge, but shrink again with age and the decline of life. Life begins and ends in a cell.—See APPLETON's *Cyclopedia*, art. "Absorption."

† See COOKE's *Religion and Chemistry*, page 236.

hours, when the fluids are not ready. A hearty supper is eaten when the body, wearied with the day's labor, demands rest. The appetite craves no food when the digestion is enfeebled, but stimulants and condiments excite it, and the unwilling organs are burdened with that which they cannot properly manage. Too great variety of dishes, rich food, tempting flavors—all lead to an overloading of the stomach. This patient, long-suffering member at last wears out. Pain, discomfort, diseases of the digestive organs, and insufficient nutrition are the penalties of violated laws.

2. *The Mumps* are a swelling of the parotid—one of the salivary glands. (See Fig. 45.) The disease is generally epidemic, and the patient should be carefully secluded for the sake of others as well as himself. The swelling may be allowed to take its course. Relief from pain is often experienced by applying flannels wrung out of hot water. Great care should be used not to check the inflammation, and on first going out after recovery, not to take cold.



PRACTICAL QUESTIONS.

1. How do clothing and shelter economize food?
2. Is it well to take a long walk before breakfast?
3. Why is warm food easier to digest than cold?
4. Why is salt beef less nutritious than fresh? *
5. What should be the food of a man recovering from a fever?

* The French Academicians found that flesh soaked in water so as to deprive it of its mineral matter and juices, lost its nutritive value, and that animals fed on it soon died. Indeed, for all purposes of nutrition, Liebig said it was no better than stones, and the utmost torments of hunger were hardly sufficient to induce them to continue the diet. There was plenty of the first class of nutritive food, but there was no medium for its solution and absorption, and hence it was useless.

6. Is a cup of black coffee a healthful close to a hearty dinner ?
7. Should ice-water be used at a meal ?
8. Why is strong tea or coffee injurious ?
9. Should food or drink be taken hot ?
10. Are fruit-cakes, rich pastry, and puddings healthful ?
11. Why are warm biscuit and bread hard of digestion ?
12. Should any stimulants be used in youth ?
13. Why should bread be made spongy ?
14. Which should remain longer in the mouth, bread or meat ?
15. Why should cold water be used in making soup, and hot in boiling meat ?
16. Name the injurious effects of over-eating.
17. Why do not buckwheat cakes, with syrup and butter, taste as well in July as in January ?
18. Why is a late supper injurious ?
19. What makes a man " bilious ?"
20. What is the best remedy ? *Ans.* Diet to give the organs rest, and active exercise to arouse the secretions and the circulation.
21. What is the practical use of hunger ?
22. How can jugglers drink when standing on their heads ?
23. Why do we relish butter on bread ?
24. Is chewing tobacco more injurious than smoking ?
25. Why should ham and sausage be thoroughly cooked ?
26. Why do we wish butter on fish, eggs with tapioca, oil on salad, and milk with rice ?
27. Explain the relation of food to exercise.
28. How do you explain the difference in the manner of eating between carnivorous and herbivorous animals ?
29. Why is a child's face plump and an old man's wrinkled ?
30. Show how life depends on repair and waste.
31. What is the difference between the decay of the teeth and the constant decay of the body ?
32. Should biscuit and cake containing yellow spots of soda be eaten ?
33. Tell how the body is composed of organs, organs are made up of tissues, and tissues of cells.
34. Why do we not need to drink three pints of water (see page 133) per day ?
35. Why, during a pestilence, are those who use liquors as a beverage the first, and often the only victims ?
36. What two secretions seem to have the same general use ?
37. How may the digestive organs be strengthened ?

VII.

NERVOUS SYSTEM

“MARK then the cloven sphere that holds
All thoughts in its mysterious folds,
That feels sensation’s faintest thrill,
And flashes forth the sovereign will ;
Think on the stormy world that dwells
Lock’d in its dim and clustering cells ;
The lightning gleams of power it sheds
Along its hollow, *glassy* threads !”

THE NERVOUS SYSTEM.*

STRUCTURE.—The nervous system includes the *brain*, the *spinal cord*, and the *nerves*. It is composed of two kinds of matter—the *white* and the *gray*. The former consists of milk-white, glistening fibres, averaging about $\frac{1}{100}$ of an inch in diameter; the latter, of small, ashen-colored cells, forming a pulp-like substance of the consistency of blanc-mange. This is often gathered in little masses, termed *ganglions* (*ganglion*, a knot), because, when a nerve passes through a group of the cells, they give it the appearance of a knot. The white fibres are conductors, while the gray cells are generators of nervous force.† The ganglia answer to the stations along a

* The organs of circulation, respiration, and digestion, of which we have already spoken, are often called the vegetative functions, because they belong also to the vegetable kingdom. Plants have a circulation of sap through their cells corresponding to that of the blood through the capillaries. They breathe the air through their leaves, which act the part of lungs, and they take in food which they change into their own structure by a process which answers to that of digestion. The plant, however, is a mere collection of parts incapable of any combined action. On the other hand, the animal has a nervous system which binds all the organs together.

† What this force is we do not know. In some respects it is like electricity, but, in others, differs materially. Its velocity is about 100 feet per second. (See *Physics*, p. 188.)

Fig. 42.



The Nervous System. A, Cerebrum; B, Cerebellum.

telegraphic line, where messages are received and transmitted, and the fibres correspond to the wires which communicate between different parts.

The Brain is the seat of the mind. Its average weight is about fifty ounces.* It is egg-shaped, and fills closely the cavity of the skull. It reposes securely on a water-bed, being surrounded by a double membrane, delicate as a spider's web, which forms a closed sack filled, like the spaces in the brain itself, with a liquid resembling water. Within this, and closely investing the brain, is a fine tissue (*pia mater*), with a mesh of blood-vessels which dips down into the hollows, and bathes them so copiously that it uses one-fifth of the entire circulation of the body. Around the whole is wrapped a tough membrane (*dura mater*), which lines the bony box of the skull, and separates the various parts of the organ by strong partitions. The brain consists of two parts—the *cerebrum* and the *cerebellum*.

The Cerebrum fills the front and upper part of the skull, and comprises about seven-eighths of the entire weight of the brain. As animals rise in the scale of life, this higher part makes its appearance. It is a mass of white fibres, with cells of gray matter sprinkled on the outside, or lodged here and there in ganglia. It is so curiously wrinkled and folded as to strikingly resemble the meat of an English walnut. This structure gives a large surface for the gray matter—sometimes as much as 670 square inches. The convolutions are not noticeable in an infant, but increase with the growth of the mind, their depth and intricacy being characteristic of high mental

* Cuvier's brain weighed 64 oz., and that of an idiot only 20 oz.

Fig. 40.



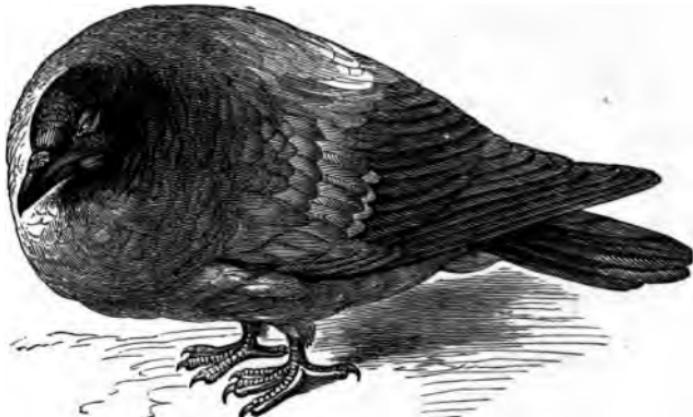
Surface of the Cerebrum.

power. The cerebrum is divided into two hemispheres, connected beneath by fibres of white matter. Thus we have two brains,* as well as two hands and two eyes. This provides us with a surplus of brains, as it were, which can be drawn upon in an emergency. A large part of one hemisphere has been destroyed without particularly injur-

* This doubleness has given rise to some curious speculations. In the case of the hand, eye, etc., we know that the sensation is made more sure. Thus we can see with one eye, but not so well as with both. It is perhaps the same with the brain. We may sometimes carry on a train of thought, "build an air-castle" with one-half of our brain, while the other half looks on and watches the operation; or may read and at the same time think of something else. So in delirium, a patient often imagines himself two persons, thus showing a want of harmony between the two halves. (See DRAPER's *Human Physiology*, page 339.)

ing the mental powers*—just as a person has been blind in one eye for a long time without having discovered his loss.

Fig. 50.



Pigeon from which the Cerebrum has been removed.

The cerebrum is the centre of intelligence and thought. Pigeons from which it is removed are plunged in profound stupor, and are inattentive to surrounding objects; they occasionally open their eyes with a vacant stare, and then relapse into their former apathy.

The Cerebellum lies below the cerebrum, and in the back part of the head. (See Fig. 48.) It is about the size of a small fist. Its structure is similar to that of the brain proper, but instead of convolutions it has parallel ridges,

* A pointed iron bar, three and a half feet long and one inch and a quarter in diameter, was driven by the premature blasting of a rock completely through the side of the head of a man who was present. It entered below the temple, and made its exit at the top of the forehead, just about the middle line. The man was at first stunned, and lay in a delirious, semi-stupefied state for about three weeks. At the end of sixteen months, however, he was in perfect health, with the wounds healed and with the mental and bodily functions unimpaired, except that the sight was lost in the eye of the injured side.—DALTON. (Note, p. 234.)

FIG. 52.



Pigeon from which the Cerebellum has been removed.

which, letting the gray matter down deeply into the white matter within, give it a peculiar appearance, called the *arbor-vita*, or tree of life. (Fig. 54.) This part of the brain is the centre for the control of the voluntary muscles. Persons in whom it is injured or diseased walk as if intoxicated, and cannot perform any orderly work. Pigeons from which it is removed are excited, nervous, and try to escape with uncertain, sprawling movements.

The Spinal Cord occupies the cavity of the backbone. It is protected by the same membranes as the brain, but, unlike it, the white fibres are on the outside, and the gray cells within. Deep fissures separate it into halves (Fig. 53), which are, however, joined by a bridge of the same substance. Just as it starts from the brain, there is an expansion called the *medulla oblongata*. (Fig. 54.)

The Nerves are hard, glistening, silvery threads, composed, like the spinal cord, of white matter without and

gray within. They ramify to all parts of the body. Often they are very near each other, yet are perfectly distinct, each conveying its own impression.* Those which carry the orders of the mind to the different organs are called the *motory* nerves; while those which bring back impressions which they receive are styled *sensory* nerves. If the sensory nerve leading to any part be cut, all sensation in that spot will be lost, while motion will remain; if the motory nerve be cut, all motion will be destroyed, while sensation will exist as before.

Transfer of Pain.—Strictly speaking, pain is not in any organ, but in the mind, since only that can feel. When any nerve brings news to the brain of an injury, the mind refers the pain to the end of the nerve. A familiar illustration is seen in the “funny bone” behind the elbow. Here the nerve (*ulnar*) gives sensation to the third and fourth fingers, in which, if this bone be struck, the pain will seem to be. Long after a limb has been amputated, pain will be felt in it, as if it still formed a part of the body—any injury in the stump being referred to the point to which the nerve formerly led. †

* Press two fingers together, and, closing the eyes, let some one pass the point of a pin lightly from one to the other; you will be able to tell which is touched, yet if the nerves came in contact with each other anywhere in their long route to the brain, you could not thus distinguish.

† Only about five per cent. of those who suffer amputation lose the feeling of the part taken away. There is something tragical, almost ghastly, in the idea of a spirit limb haunting a man through his life, and betraying him in unguarded moments into some effort, the failure of which suddenly reminds him of his loss. A gallant fellow, who had left an arm at Shiloh, once, when riding, attempted to use his lost hand to grasp the reins while with the other he struck his horse. A terrible fall was the result of his mistake. When the current of a battery is applied to the nerves of an arm-stump, the irritation is carried to the brain, and referred to all the regions of the lost limb. On one occasion the shoulder was thus electrized three inches above the point where the limb was cut off. For two years the man had ceased to be conscious of his limb. As the current passed through, ignorant of its possible effects, he started up, crying,

The nerves are divided into three general classes—the *spinal*, the *cranial*, and the *sympathetic*.

Fig. 52.



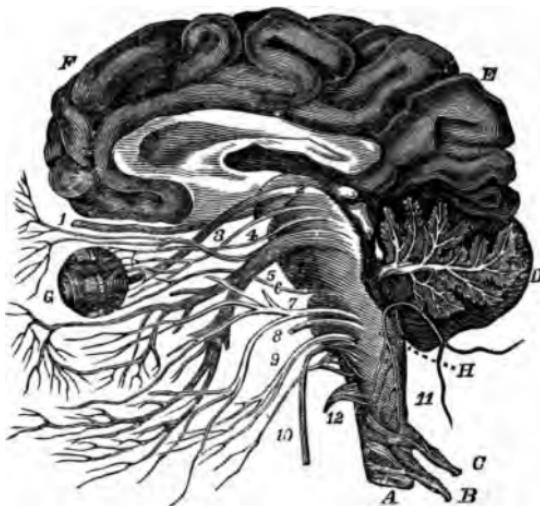
A, posterior root of a spinal nerve; E, ganglion; B, anterior root; D, spinal nerve.

The Spinal Nerves, of which there are thirty-one pairs, issue from the spinal cord through apertures provided for them in the backbone. Each nerve arises by two roots; the anterior is the motory, and the posterior the sensory one. The posterior alone connects directly with the gray matter of the cord, and has a small ganglion of gray matter of its own at a little distance from its origin. These roots soon unite, i. e., are bound up in one sheath, though they preserve their special functions. When the posterior root of a nerve is cut, the animal loses the power of feeling, and when the anterior root is cut, that of motion. If both roots are cut, the part of the body supplied by that nerve will become paralyzed, motion and feeling being destroyed.

The Cranial Nerves, twelve pairs in number, spring from the lower part of the brain and the medulla oblongata.

"Oh, the hand! the hand!" and tried to seize it with the living grasp of the sound fingers. No resurrection of the dead could have been more startling.—Dr. MITCHELL on "Phantom Limbs." *Lippincott's Magazine*.

Fig. 64.



The Brain and the origin of the twelve pairs of Cranial Nerves. F, E, the cerebrum; D, the cerebellum, showing the arbor-vitæ; G, the eye; H, the medulla oblongata; A, the spinal cord; C and B, the first two pairs of spinal nerves.

1. The *olfactory*, or first pair of nerves, ramify through the nostrils, and are the nerves of smell.
2. The *optic*, or second pair of nerves, pass to the eyeballs, and are the nerves of vision.
- 3, 4, 6. The *motores oculi* (eye-movers) are three pairs of nerves used to move the eyes.
5. The *trifacial*, or fifth pair of nerves, divide each into three branches—hence the name: the first to the upper part of the face, eyes, and nose; the second to the upper jaw and teeth; the third to the lower jaw and the mouth, where it forms the nerve of taste. These nerves are implicated when we have the toothache or neuralgia.
7. The *facial*, or seventh pair of nerves, are distributed over the face, and give to it expression.*

* "If it is palsied, on one side there will be a blank, while the other side will laugh or cry, and the whole face will look funny indeed. There were some cruel people in the middle ages who used to cut the nerve and deform children's faces

8. The *auditory*, or eighth pair of nerves, go to the ears, and are the nerves of hearing.

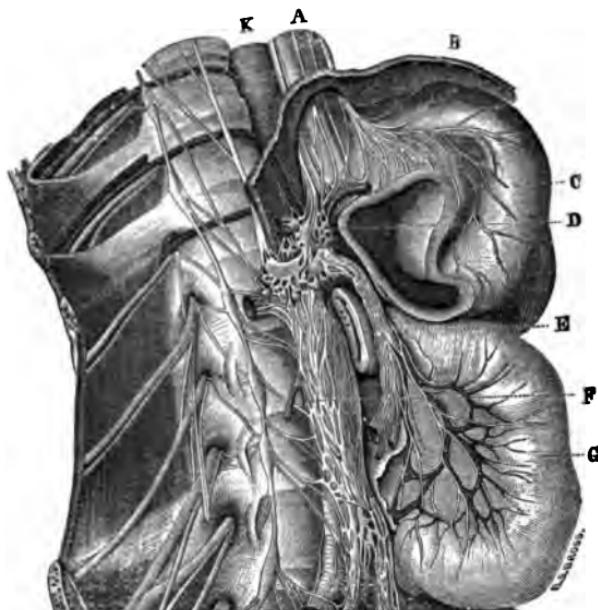
9. The *glo-so-pha-ryn'-ge-al*, or ninth pair of nerves, are distributed over the mucous membrane of the pharynx, tonsils, etc.

10. The *pneu-mo-gas'-tric*, or tenth pair of nerves, preside over the larynx, lungs, liver, stomach, and one branch extends to the heart. This is the only nerve which goes so far from the head.

11. The *accessory*, or eleventh pair of nerves, rise from the spinal cord, run up to the medulla oblongata, and thence leave the skull at the same opening with the ninth and tenth pairs. They regulate the vocal movements of the larynx.

12. The *hy-po-glos'-sal*, or twelfth pair of nerves, give motion to the tongue.

Fig. 55.



Spinal Nerves, Sympathetic Cord, and the Net work of Sympathetic Nerves around the Internal Organs. K, aorta; A, esophagus; B, diaphragm; C, stomach.

in this way, for the purpose of making money of them at shows. When this nerve was wrongly supposed to be the seat of neuralgia, or tic-douloureux, it was often cut by surgeons. The patient suffered many dangers, and no relief of pain was gained."—MAPOTHER.

The Sympathetic System consists of a double chain of ganglia on either side of the backbone, extending into the chest and abdomen. From these, delicate nerves run to the organs on which life depends—the heart, lungs, stomach, etc.—to the blood-vessels, and to the spinal and cranial nerves over the body. Thus the entire system is bound together with cords of sympathy, so that, “if one member suffers, all the members suffer with it.”

Here lies the secret of the control exercised by the brain over all the vital operations. Every organ responds to its changing moods, especially those of respiration, circulation, digestion, and secretion,—processes intimately linked with this system, and controlled by it.

Crossing of Cords.—Each half of the body is presided over, not by its own half of the brain, but that of the opposite side. The nerve fibres, descending from the brain, cross each other. When derangement occurs in one half of the brain, the opposite half of the body is deprived of feeling and motion. The nerves going to the face do not thus cross, and therefore the face may be motionless on one side, and the limbs on the other. The sensory fibres of the spinal nerves also cross, so that an injury to the spinal cord may cause a loss of motion in one leg and of feeling in the other.

Reflex Action.—Since the gray matter generates the nervous force, a ganglion is capable of receiving an impression, and of sending back or *reflecting* it so as to excite the muscles to action. This is done without the consciousness of the mind.* Thus we wink involuntarily at a

* Instances of an unconscious working of the mind are abundant. Abercrombie, in his *Intellectual Powers*, gives the following:

“A lawyer had been excessively perplexed about a very complicated question.

flash of light or a threatened blow.* We start at a sudden sound. We jump back from a precipice before the mind has time to reason upon the danger. The spinal cord conducts certain impressions to the brain, but responds to others without troubling that organ.† The medulla ob-

An opinion was required from him, but the question was one of such difficulty that he felt very uncertain how he should render it. The decision had to be given at a certain time, and he awoke in the morning of that day with a feeling of great distress. He said to his wife, 'I had a dream, and the whole thing was clearly arranged before my mind, and I would give anything to recover the train of thought.' His wife said to him, 'Go and look on your table.' She had seen him get up in the night and go to his table and sit down and write. He did so, and found there the opinion which he had been most earnestly endeavoring to recover, lying in his own handwriting. There was no doubt about it whatever."

In this case the action of the brain was clearly automatic, i. e., reflex. The lawyer had worried his brain by his anxiety, and thus prevented his mind from doing its best. But it had received an impulse in a certain direction, and when left to itself, worked out the result. (See Questions in Appendix for other illustrations.)

* "A very eminent chemist a few years ago was making an experiment upon some extremely explosive compound which he had discovered. He had a small quantity of this compound in a bottle, and was holding it up to the light, looking at it intently; and whether it was a shake of the bottle or the warmth of his hand, I do not know, but it exploded in his hand, and the bottle was shivered into a million of minute fragments, which were driven in every direction. His first impression was, that they had penetrated his eyes, but to his intense relief he found presently that they had only struck the outside of his eyelids. You may conceive how infinitesimally short the interval was between the explosion of the bottles and the particles reaching his eyes; and yet in that interval the impression had been made upon his sight, the mandate of the reflex action, so to speak, had gone forth, the muscles of his eyelids had been called into action, and he had closed his eyelids before the particles had reached them, and in this manner his eyes were saved. You see what a wonderful proof this is of the way in which the automatic action of our nervous apparatus enters into the sustenance of our lives, and the protection of our most important organs from injury."—DR. CARPENTER.

† There is a story told of a man, who having injured his spinal cord, had lost feeling and motion in his lower extremities. Dr. John Hunter experimented upon him. Tickling his feet, he asked him if he felt it; the man, pointing to his limbs which were kicking vigorously about, answered, "No, but you see my legs do."

Illustrations of this independent action of the spinal cord are common in animals. A headless wasp will ply its sting energetically. A fowl, after its head is cut off, will flap its wings and jump about as if in pain, although, of course, all sensation has ceased. "A water beetle, having had its head removed, remained motionless as long as it rested on a dry surface, but when cast into water, it

longata carries on the process of respiration. The great sympathetic system binds together all the organs of the body.

Uses of Reflex Action.—We breathe eighteen times every minute; we stand erect without a consciousness of effort;* we walk, eat, digest, and at the same time carry on a train of thought. Our brain is thus emancipated from the petty detail of life. If we were obliged to attend to every breath, every pulsation of the heart, every wink of the eye, our time would be wasted in keeping alive. More standing would require our entire attention. Besides, an act which at first demands all our thought soon requires less, and at last becomes mechanical,† as we say, i. e., reflex. Thus we play a familiar tune upon an instrument and carry on a conversation at the same time. All the possibilities of an education and the power of forming habits are based upon this principle. No act we perform ends with itself. It leaves behind it in the nervous centres a tendency to do the same thing again. Our physical being thus conspires to fix upon us the habits of a good or an evil life. Our very thoughts are written in our mus-

executed the usual swimming motions with great energy and rapidity, striking all its comrades to one side by its violence, and persisting in these for more than half an hour."

* In this way we account for the perilous feats performed by the somnambulist. He is not conscious, as his operations are not directed by the cerebrum, but by the other nervous centres.

† "As every one knows," says Huxley, "it takes a soldier a long time to learn his drill—for instance, to put himself into the attitude of 'attention' at the instant the word of command is heard. But, after a time, the sound of the word gives rise to the act, whether the soldier be thinking of it or not. There is a story, which is credible enough, though it may not be true, of a practical joker, who, seeing a discharged veteran carrying home his dinner, suddenly called out 'Attention!' whereupon the man instantly brought his hands down, and lost his mutton and potatoes in the gutter. The drill had been thorough, and its effects had become embodied in the man's nervous structure."

cles, so that the expression of our face and even our features grow into harmony with the life we live.

Brain Exercise.—The nervous system demands its life and activity. The brain grows by what it feeds on. One who reads mainly light literature, who lolls on the sofa or worries through the platitudes of an idle or a fashionable life, decays mentally; his system loses tone, and physical weakness follows mental poverty. On the other hand, an excessive use of the mind withdraws force from the body, whose weakness, reacting on the brain, produces gradual decay and serious diseases.

Sleep* is as essential as food. During the day, the process of tearing down goes on; during the night, the work of building up should make good the loss. In youth more sleep is needed than in old age, when nature makes few permanent repairs, and is content with temporary expedients. The number of hours required for sleep must be decided by each person. Napoleon took only five hours, but most people need from six to eight hours—brain-workers even more. In general, one should sleep until he naturally wakes. If one's rest be broken, it should be made up as soon as possible.

The Effect of Alcohol upon the Nervous System.—1. *The Stage of Excitement.*—The outposts of the nerves are paralyzed. The force, now drawn in to

* Sleep procured by medicine is rarely as beneficial as that secured naturally. The disturbance to the nervous system is often sufficient to counterbalance all the good results. The habit of seeking sleep in this way, without the advice of a physician, is to be deprecated. The dose must be constantly increased to produce the effect, and thus great injury may be caused. Often, too, where laudanum or morphine is used, the person unconsciously comes into a terrible and fatal bondage. Especially should infants never be dosed with cordials, as is the common family practice. The damage done to helpless childhood by the ignorant and reckless use of soothing syrups is frightful to contemplate.

the nervous centres, drives the machinery of life with tremendous energy. The heart jumps like the mainspring of a watch when the resistance of the wheels is removed. The blood surges through the body with increased force. Every capillary tube in the system is swollen and flushed, like the reddened nose and cheek.*

2. *The Stage of Muscular Weakness.*—If the influence be still continued, the alcohol acts upon the spinal cord. The control of some of the muscles is lost. Those of the lower lip usually fail first, then the lower limbs, and the staggering, uncertain steps betray the result. The temperature, which for a time was slightly increased, soon begins to fall as the heat is radiated, and, as the result, the body is cooled.

3. *The Stage of Mental Weakness.*—The cerebrum is now implicated. The centre of thought and will being overpowered, the mind is a chaos. The reason giving way, the animal instincts assume the mastery of the man. The coward shows himself more craven, the braggart more boastful, the bold more daring, and the cruel more brutal. At last prostration ensues, and the wild, mad revel of the drunkard ends in utter insensibility. Fortunately the two nervous centres which supply the heart and the diaphragm are the slowest to be influenced. So, even in this final stage, the breathing and the circulation still go on, though the other organs have all stopped. Were it not for this, every person thoroughly intoxicated would die. In all this, there is stimulation, but no nourishment, no permanent power conferred on brain or muscle.

* In time, this condition of the capillaries becomes chronic, and we see the signs of it in the red nose and fiery face of the toper.

13. Why can an idle scholar read his lesson and at the same time count the marbles in his pocket?
14. In amputating a limb, what part, when divided, will cause the keenest pain?
15. What is the effect of bad air on nervous people?
16. Is there any truth in the proverb that "he who sleeps, dines?"
17. What does a high, wide forehead indicate?
18. How does indigestion frequently cause a headache?
19. What is the cause of the foot's being "asleep?" *
20. When an injury to the nose has been remedied by transplanting skin from the forehead, why is a touch to the former felt in the latter?
21. Are closely-curtained windows healthful?
22. Why, in falling from a height, do the limbs instinctively take a position to defend the important organs?
23. What causes the pylorus to open and close at the right time?
24. Why is pleasant exercise most beneficial?
25. Why does grief cause one to lose his appetite?
26. Why should we never study directly after dinner?
27. What produces the peristaltic movement of the stomach?
28. Why is a healthy child so restless and full of mischief?
29. Why is a slight blow on the back of a rabbit's neck fatal?
30. Why can one walk and carry on a conversation at the same time?
31. What are the dangers of over-study?
32. What is the influence of idleness upon the brain?
33. State the close relation which exists between physical and mental health and disease.
34. In what consists the value of the power of habit?
35. How many pairs of nerves supply the eye?
36. Describe the reflex actions in reading aloud.
37. Under what circumstances does paralysis occur?
38. If the eye-lids of a profound sleeper were raised, and a candle brought near, would the iris contract?
39. How does one cough in his sleep?
40. Give illustrations of the unconscious action of the brain.

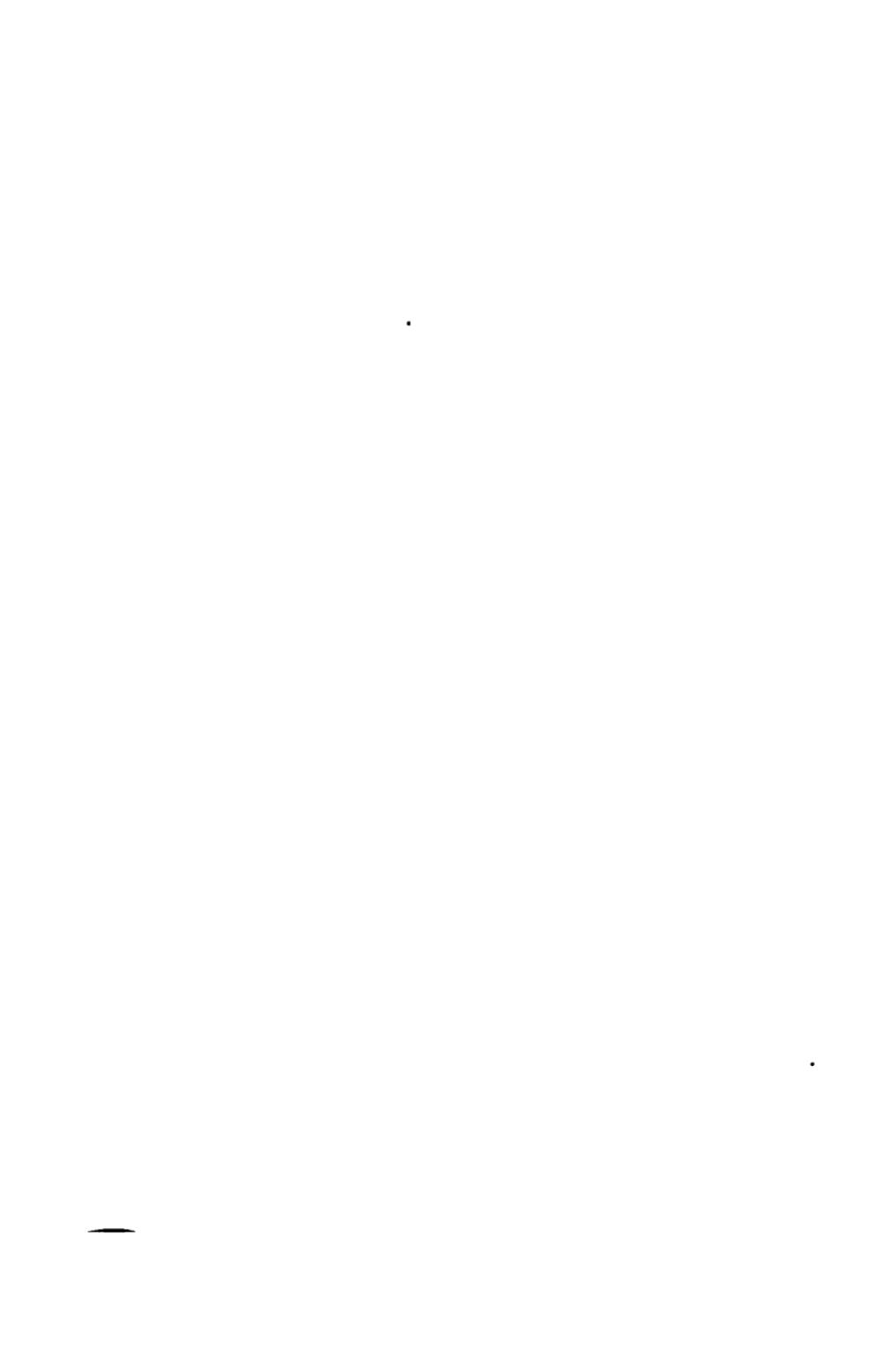
* "Here the nervous force is prevented from passing by compression. Just how this is done, or what is kept from passing, we cannot tell. If a current of electricity were moving through a rubber tube full of mercury, a slight squeeze would interrupt it. These cases may depend on the same general principle, but we cannot assert it."—HUXLEY. The tingling sensation caused by the compression is transferred to the foot, whence the nerve starts.

VIII.

SPECIAL SENSES

“SEE how yon beam of seeming white
Is braided out of seven-hued light ;
Yet in those lucid globes no ray
By any chance shall break astray.
Hark, how the rolling surge of sound,
Arches and spirals circling round,
Wakes the hush’d spirit through thine ear
With music it is heaven to hear.”

HOLMES.



THE SPECIAL SENSES.

I. TOUCH.

DESCRIPTION.—Touch is sometimes called the “common sense,” since its nerves are spread over the whole body. It is most delicate, however, in the point of the tongue and tips of the fingers. The surface of the cutis is covered with minute, conical projections called *papillæ*.* (Fig. 24.) Each of these contains its tiny nerve-twigs, which receive the impression and transmit it to the brain, where the perception is produced.

Uses.—Touch is the first of the senses used by a child. By it we obtain our idea of solidity, and throughout life rectify all other sensations. Thus, when we see anything curious, our first desire is to handle it.

The sensation of touch is generally relied upon, yet if we hold a marble in the manner shown in Fig. 56, it will seem like two marbles; and if we touch the fingers thus crossed to our tongue, we shall feel two tongues. Again, if we close our eyes and let another person move one of our fingers over a plane surface, first lightly, then with greater pressure, and then lightly again, we shall think the surface concave.

* In the palm of the hand, where there are 12,000 in a square inch, we can see the fine ridges along which they are arranged.

Fig. 56.



This organ is capable of wonderful cultivation. The physician acquires by practice the *tactus eruditus*,* or learned touch, which is often of great service. The delicacy of touch possessed by the blind almost compensates the loss of the absent sense.†

* An educated sense of touch was possessed by the late Dr. March of Albany, to a remarkable degree. It had been cultivated and perfected in the course of extensive surgical practice to such an extent as to become delicate, precise, and nearly unfailing as a means of diagnosis. On one occasion the Doctor was summoned to see a man who was supposed to have extensive cancerous disease of the thigh, which had been developing many months. The importance of the case had called an unusual number of physicians to the bedside of the patient, and after very thorough examination of the unyielding swelling by them all, Dr. March subjected it to close scrutiny, using his fingers with astonishing caution and delicacy, and appearing to be absorbed in the investigation. A consultation followed in an adjoining room, and from the youngest to the oldest, opinions were expressed that the tumor was malignant in character and called for amputation of the thigh, as affording the only means of arresting the disease, or of saving or prolonging life. Dr. March dissented from this view, and boldly stated that the swelling was an abscess, which could be emptied by a free incision. The reputation of the surgeon, and the positiveness of his assertion, caused his advice to be heeded, and he was permitted to make an attempt to reach the matter, under mental protest of his associates that he would fail in his expectations. The patient, willing to believe almost against hope, suffered the Doctor to proceed with the operation. Taking a scalpel, and guided by his fingers in selecting a location, he made a deep incision through the dense structures of the thigh. Nothing but blood flowed from the wound. A second plunge of the knife brought such an overwhelming discharge of pus from the immensely-distended cavity, as to amount in the quantity collected to several pints. Rapid recovery followed and the limb was saved.—WM. C. WY.

† The sympathy between the different organs shows how they all combine to make a home for the mind. When one sense fails, the others endeavor to remedy the defect. It is touching to see how the blind man gets along without eyes, and the deaf without ears. Cuthbert, though blind, was the most efficient polisher of telescopic mirrors in London. Saunderson, the successor of Newton

II. TASTE.

Fig. 57.



The Tongue, showing the three kinds of Papillæ—the conical (D), the whip-like (K, I), the circumvallate or entrenched (H, L); E, F, G, nerves; C, glottis.—LANKESTER.

Description.—This sense is located in the papillæ of the tongue and palate. These papillæ start up when tasting, as you can see by placing a drop of vinegar on another

as professor of mathematics at Cambridge, could distinguish between real and spurious medals. There is an instance recorded of a blind man who could recognize colors. The author knew one who could tell when he was approaching a tree, as he said, by the different feeling of the air.

person's tongue, or your own, before a mirror. The velvety look of this organ is given by hair-like projections of the cuticle upon some of the papillæ. They absorb the liquid to be tasted, and convey it to the nerves.* The back of the tongue is most sensitive to salt and bitter substances, and as this part is supplied by the ninth pair of nerves (Fig. 54), which is in sympathy with the stomach, such flavors often produce vomiting. The edges of the tongue are most sensitive to sweet and sour substances, and as this part is supplied by the fifth pair of nerves, which also goes to the face, an acid, by sympathy, distorts the countenance.

The Use of the Taste was originally to guide in the selection of food ; but it has become so depraved by condiments and the force of habit that it would be a difficult task to tell what are one's natural tastes.



III. SMELL.†

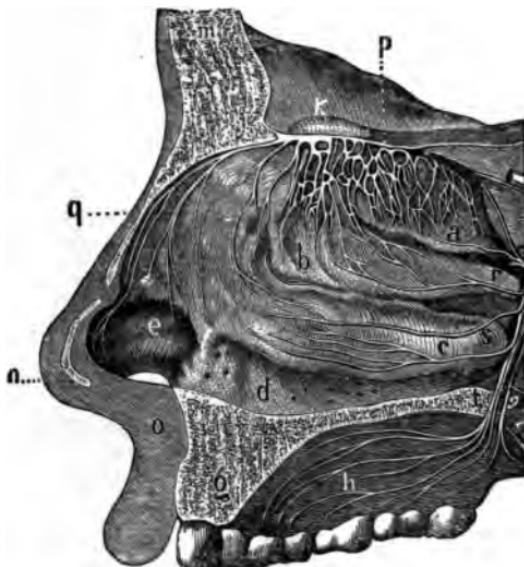
Description.—The nose, the seat of this sense, is composed of cartilage covered with muscles and skin, and joined to the skull by small bones. The nostrils open at the back into the pharynx, and are lined by a continuation of the mucous membrane of the throat. The olfactory nerves (first pair, Fig. 54) enter through a sieve-like, bony plate at the roof of the nose, and are distributed over the inner surface of the two olfactory chambers.

* An insoluble substance is therefore tasteless.

† The sense of smell is so intimately connected with that of taste that we often fail to distinguish between them. Garlic, vanilla, coffee, and various spices, which seem to have such distinct taste, have really a powerful odor but a feeble flavor.

The object to be smelled need not touch the nose, but tiny particles borne on the air enter the nasal passages.*

Fig. 58.



A, b, c, d, interior of the nose, which is lined by a mucous membrane; n, the nose; e, the wing of the nose; q, the nose-bones; o, the upper lip; g, section of the upper jaw-bone; h, the upper part of the mouth, or hard palate; m, frontal bone of the skull; k, the ganglion or bulb of the olfactory nerve in the skull, from which are seen the branches of the nerve passing in all directions.

* "Three-quarters of a grain of musk placed in a room cause a very powerful smell for a considerable length of time without any sensible diminution in weight, and the box in which musk has been placed retains the perfume for almost an indefinite period. Haller relates that some papers which had been perfumed by a grain of ambergris, were still very odoriferous after a lapse of forty years.

"Odors are transported by the air to a considerable distance. A dog recognizes his master's approach by smell even when he is far away; and we are assured by navigators that the winds bring the delicious odors of the balmy forests of Ceylon to a distance of ten leagues from the coast.

"Even after making due allowance for the effects of the imagination, it is certain that odors act as an excitant on the brain, which may be dangerous when long continued. They are especially dreaded by the Roman women. It is well known that in ancient times the women of Rome indulged in a most im-

The Uses of the sense of smell are to guide us in the choice of our food, and to warn us against bad air and unhealthy localities.

IV. HEARING.

Fig. 59.



The Ear.

Description.—The ear is divided into the *external*, *middle*, and *internal* ear.

moderate use of baths and perfumes; but those of our times have nothing in common with them in this respect; and the words of a lady are quoted, who said on admiring an artificial rose, 'It is all the more beautiful that it has no smell.'

"We are warned by the proverb not to discuss colors or tastes, and we may add odors also. Men and nations differ singularly in this respect. The Laplander and the Esquimaux find the smell of fish-oil delicious. Wrangel says his compatriots, the Russians, are very fond of the odor of pickled cabbage, which forms an important part of their food; and asafoetida, it is said, is used as a condiment in Persia, and, in spite of its name, there are persons who do not find its odor disagreeable any more than that of valerian."—*Wonders of the Human Body.*

1. *The External Ear* is a sheet of cartilage curiously folded for catching sound. The auditory canal, *B*, or tube of this ear-trumpet, is about an inch long. Across the lower end is stretched *the membrane of the tympanum* or drum, which is kept soft by a fluid wax.

2. *The Middle Ear* is a cavity, at the bottom of which is the Eustachian tube, *G*, leading to the mouth. Across this chamber hangs a chain of three singular little bones, *C*, named from their shape the *hammer*, the *anvil*, and the *stirrup*. All together these tiny bones weigh only a few grains, yet they are covered by a periosteum, are supplied with blood-vessels, and articulate with perfect joints (one a ball-and-socket, the other a hinge), having synovial membranes, cartilages, ligaments, and muscles.

3. *The Internal Ear*, or labyrinth, as it is sometimes called from its complex character, is hollowed out of the solid bone. In front is the vestibule or ante-chamber, *A*, about as large as a grain of wheat; from it open three *semi-circular canals*, *D*, and the winding stair of the *cochlea*, or snail shell, *E*. Here expand the delicate fibrils of the auditory nerve. Floating in the liquid which fills the labyrinth is a little bag containing hair-like bristles, fine sand, and two ear-stones (*otoliths*). All these knocking against the ends of the nerves, serve to increase any impulse given to the liquid in which they lie. Finally, to complete this delicate apparatus, in the cochlea are minute tendrils, named the fibres of Corti, from their discoverer. These are regularly arranged—the longest at the bottom, and the shortest at the top. If this spiral plate, which coils two and a half times around, could be unrolled and made to stand upright, it would form a beautiful microscopic harp of three thousand strings. If it were possible to strike

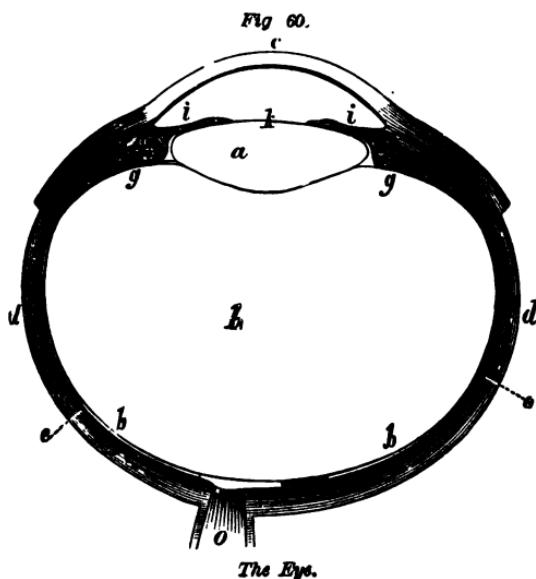
these cords as one can the keyboard of a piano, he could produce in the mind of the person experimented upon every variety of tone which the ear can distinguish.

How We Hear.—Whenever one body strikes another in the air, waves are produced, just as when we throw a stone into the water a series of concentric circles surrounds the spot where it sinks. These waves of air strike upon the membrane. This vibrates, and sends the motion along the chain of bones in the middle ear to the fluids of the labyrinth. Here bristles, sand, and stones pound away, and the wondrous harp of the cochlea, catching up the pulsations,* carries them to the fibres of the auditory nerve, which conveys them to the brain, and gives the mind the idea of sound. (*Physics*, p. 176.)

Care of the Ear.—The delicacy of the ear is such that it needs the greatest care. Cold water should not be allowed to enter the auditory canal. If the wax accumulate, never remove it with a hard instrument, lest the delicate membrane be injured, but with a little warm water, after which turn the head to let the water run out, and wipe the ear dry. The hair around the ears should never be left wet, as it may chill this sensitive organ. If an insect get into the external ear, pour in a little oil to kill it, and then remove with tepid water. The object of the Eustachian tube is to admit air into the ear, and thus equalize the pressure on the membrane. If it become closed by a cold, or if, from any cause, the pressure be made unequal, so as to produce an unpleasant feeling in the ear, relief may often be obtained by grasping the nose and forcibly swallowing.

* The original motion is constantly modified by the medium through which it passes. The bristles, otoliths, and Cortian fibres of the ear and the rods and cones of the eye (p. 189) seem to convert the vibrations into pulsations which act as *stimuli* of the appropriate nerve. The molecular change thus produced in the *ve-fibres* is propagated to the brain.

V. SIGHT.



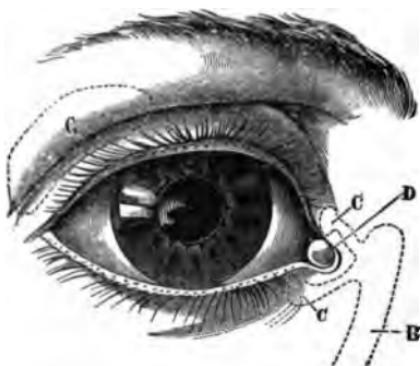
Description.—The eye is lodged in a bony cavity, protected by the overhanging brow. It is a globe, about an inch in diameter. The ball is covered by three coats—(1) the *sclerotic*, *d*, a tough, hard casing, which gives form to the eye, the convex, transparent part in front forming a window, the cornea, *c*; (2) the *choroid*, *e*, a black lining, to absorb the superfluous light;* and (3) the *retina*, *b*, the expansion of the optic nerve, *o*. The eye is divided into the anterior and posterior chambers. In the front part of the latter, is the crystalline lens, *a*, which serves to bring the rays of light to a focus on the retina. The

* Neither white rabbits nor albinos have this black lining, and hence their sight is confused.

lens is kept in place by the ciliary processes, *g*, which are arranged like the rays in the disk of a passion-flower. The anterior chamber is filled with the aqueous humor—a limpid liquid, and the posterior with the vitreous humor. The pupil, *k*, is a hole in the colored, muscular curtain, *i*, the *iris* (rainbow).

Eyelids and Tears.—The eyelids are close-fitting shutters to protect the eye. The inner side is lined with a mucous membrane, which is exceedingly sensitive, and thus aids in protecting the eye from any irritating sub-

Fig. 61.



The Eyelashes and the Tear-glands.

stance. The looseness of the skin favors swelling from inflammation or the effusion of blood, as in a "black eye." The eyelashes serve as a kind of sieve to exclude the dust, and, with the lids, to shield against a blinding light. Just within the lashes are oil glands, which lubricate the edges of the lids, and prevent them from adhering to each other. The tear or *lachrymal* gland, *G*, is an oblong body lodged in the bony wall of the orbit. It empties by sev-

eral ducts upon the inner surface, at the outer edge of the upper eyelid. Thence the tears, washing the eye, run into the *lachrymal lake*, *D*, a little basin with a rounded border fitted for their reception. On each side of this lake two canals, *C*, *C*, drain off the overplus through the duct, *B*, into the nose. In old age and in disease, these canals fail to conduct the tears away, and hence the lachrymal lake overflows upon the face.

Structure of the Retina.—In Fig. 62 is shown a section of the retina, greatly magnified, since this membrane never exceeds $\frac{1}{60}$ of an inch in thickness. On the inner surface next the vitreous humor is a lining membrane not shown in the cut; next the choroid, and comprising about $\frac{1}{2}$ the entire thickness of the retina, is a vast multitude of transparent, colorless, microscopic rods, *a*, evenly arranged and packed side by side, like the seeds on the disk of a sunflower. Among them, at regular intervals, are interspersed the cones, *b*. Delicate nerve fibres pass from the ends of the rods and cones, each expanding into a granular body, *c*, thence weaving a mesh, *d*, and again expanding into the granules, *f*. Last is a layer of fine nerve fibres, *g*, and gray, ganglionic cells, *h*, like the gray matter of the brain, whence filaments extend into *i*, the fibres of the optic nerve.

The layer of rods and cones is to the eye what the

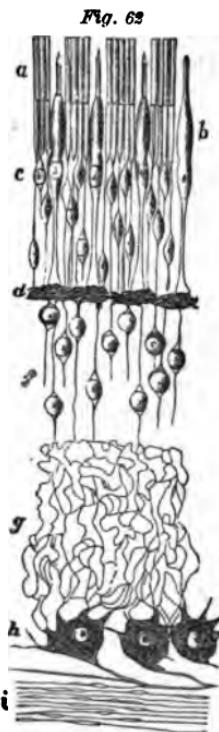


Fig. 62
Structure of the Retina.

bristles, otoliths, and *Certian* fibres are to the ear. Indeed, the nerve itself is insensible to light. At the point where it enters the eye, there are no rods and cones, and

Fig. 63.



this is called the *blind spot*. A simple experiment will illustrate the fact. Hold this book directly before the face, and, closing the left eye, look steadily with the right at the left-hand circle in Fig. 63. Move the book back and forth, and a point will be found where the right-hand circle vanishes from sight. At that moment its light falls upon the spot where the rods and cones are lacking.

How We See.—There is believed to be a kind of universal atmosphere, termed *ether*, filling all space. This substance is infinitely more subtle than the air, and occupies its pores, as well as those of all other substances. As sound is caused by waves in the atmosphere, so light is produced by waves in the ether. A lamp-light, for example, sets in motion waves of ether, which pass in through the pupil of the eye to the retina, where the rods and cones transmit the vibration through the optic nerve to the brain, and then the mind sees the light. (Note, p. 186.)

The Use of the Crystalline Lens.*—A convex lens, as a common burning-glass, bends the rays of light which

* The uses of the eye are largely dependent upon the principles of Optics and Acoustics. They are therefore best treated in philosophy.

pass through it, so that they meet at a point called the *focus*. The crystalline lens converges the rays of light

Fig. 64.

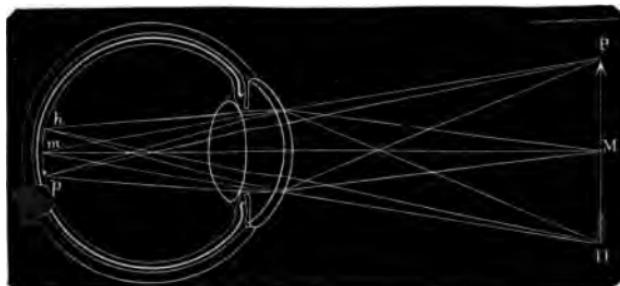


Diagram showing how an image of an object is formed upon the retina by the Crystalline Lens.

which enter the eye, and brings them to a focus on the retina.* The healthy lens has a power of changing its convexity so as to adapt† itself to near and to distant objects. (See Fig. 65.)

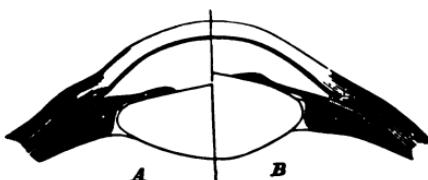
Near and Far Sight.—If the lens be too convex, it will bring the rays to a focus before they reach the retina; if too flat, they will reach the retina before coming to a focus. In either case, the sight will be indistinct. A

* The cornea and the humors of the eye act in the same manner as the crystalline lens, but not so powerfully.

† The simplest way of experimenting on the "adjustment of the eye" is to stick two stout needles upright into a straight piece of wood,—not exactly, but nearly in the same straight line, so that, on applying the eye to one end of the piece of wood, one needle (*A*) shall be seen about six inches off, and the other (*B*) just on one side of it, at twelve inches distance.

If the observer looks at the needle *B* he will find that he sees it very distinctly, and without the least sense of effort; but the image of *A* is blurred and more or less double. Now, let him try to make this blurred image of the needle *A* distinct. He will find he can do so readily enough, but that the act is accompanied by a sense of fatigue. And in proportion as *A* becomes distinct, *B* will become blurred. Nor will any effort enable him to see *A* and *B* distinctly at the same time.—HUXLEY.

Fig. 65.



Adjustment of the Crystalline Lens. A, for far objects, and B, for near.

more common defect, however, is in the shape of the globe of the eye, which is either flattened or elongated. In the former case (see *G*, Fig. 66), objects at a distance can be seen most distinctly—hence that is called far-sightedness.* In the latter, objects near by are clearer, and hence this is termed near-sightedness. Far-sightedness is remedied

Fig. 66.

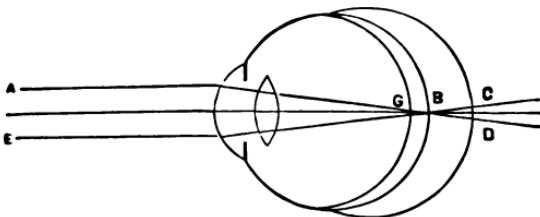


Diagram illustrating the position of the Retina.—B, in natural sight; G, in far sight; and C, in near sight.

by convex glasses; near-sightedness, by concave. When glasses will improve the sight, they should be worn; † any

* This should not be confounded with the long sight of old people, which is caused by the stiffness of the ciliary muscles, whereby the lens cannot adapt itself to the varying distances of objects.

† Dr. Henry W. Williams, the celebrated ophthalmologist, says that, in some cases, glasses are more necessary at six or eight years of age than to the majority of healthy eyes at sixty. Sometimes children find accidentally that they can see better through grandmother's spectacles. They should then be supplied with their own.

delay will be liable to injure the eyes, by straining their already impaired power. Cataract is a disease in which there is an opacity of the crystalline lens or its capsules, which obscures the vision. The lens may be caused to be absorbed, or may be removed by a skillful surgeon, and the defect remedied by wearing convex glasses.

Care of the Eyes.—The shape of the eye cannot be changed by rubbing and pressing it, as many suppose, but the sight may thus be fatally injured. Children troubled by near-sightedness should not lean forward at their work, as thus the vessels of the eye become overcharged with blood. They should avoid fine print, and try, in every possible way, to spare their eyes. If middle age be reached without especial difficulty of sight, the person is comparatively safe. Most cases of squinting are caused by long-sightedness, the muscles being strained in the effort to obtain distinct vision. In childhood, it may be cured by a competent surgeon, who will generally cut the muscle which draws the eye out of place. Healthy eyes even should never be used to read fine print or by a dim light. Serious injury may be caused by an imprudence of this kind.

Reading upon the cars is also a fruitful source of harm. The lens, striving to adapt itself to the incessantly varying distance of the page, soon becomes wearied. Objects which get into the eye should be removed before they cause inflammation; rubbing in the mean time only irritates and increases the sensitiveness. If the eye be shut for a few moments, so as to let the tears accumulate, and the upper lid be then lifted by taking hold of it at the centre, the cinder or dust is often washed away at once. Trifling objects can be removed by simply drawing the

upper lid as far as possible over the lower one; when the lid flies back to its place, the friction will detach any light substance. If it becomes necessary, turn the upper lid over a pencil, and the intruder may then be wiped off with a handkerchief. "Eye-stones" are a popular delusion. When they seem to take out a cinder, it is only because they raise the eyelid, and allow the tears to wash it out. No one should ever use an eye-wash, except by medical advice. The eye is too delicate an organ to be trifled with, and when any disease is suspected, a reliable physician should be consulted. This is especially necessary, since, when one eye is injured, the other, by sympathy, is liable to become inflamed, and perhaps be destroyed. When reading or working, the *light should be at one side, and never in front*. The position of school-room desks is, therefore, of great importance.

PRACTICAL QUESTIONS.

1. Why does a laundress test the temperature of her flat-iron by holding it near her cheek?
2. When we are cold, why do we spread the palms of our hands before the fire?
3. What is meant by a "furred tongue?"
4. Why has sand or sulphur no taste?
5. What was the origin of the word palatable?
6. Why does a cold in the head injure the flavor of our coffee?
7. Name some so-called flavors which are really sensations of touch.
8. What is the object of the hairs in the nostrils?
9. What use does the nose subserve in the process of respiration?
10. Why do we sometimes hold the nose when we take unpleasant medicine?
11. Why was the nose placed over the mouth?

12. Describe how the hand is adapted to be the instrument of touch.
13. Besides being the organ of taste, what use does the tongue subserve?
14. Why is not the act of tasting complete until we swallow?
15. Why do all things have the same flavor when one's tongue is "furred" by fever?
16. Which sense is the more useful—hearing or sight?
17. Which coat is the white of the eye?
18. What makes the difference in the color of eyes?
19. Why do we snuff the air when we wish to obtain a distinct smell?
20. Why do red-hot iron and frozen mercury (-40°) produce the same sensation?
21. Why can an elderly person drink tea which to a child would be unbearably hot?
22. Why does an old man hold his paper so far from his eyes?
23. Would you rather be punished on the tips of your fingers than on the palm of your hand?
24. What is the object of the eyelashes? Are the hairs straight?
25. What is the use of winking?
26. When you wink, do the eyelids touch at once along their whole length? Why?
27. How many rows of hairs are there in the eyelashes?
28. Do all nations have eyes of the same shape?
29. Why does snuff-taking cause a flow of tears?
30. Why does a fall cause one to "see stars?"
31. Why can we not see with the nose, or smell with the eyes?
32. What causes the roughness of a cat's tongue?
33. Is the cuticle essential to touch?
34. Can one tickle himself?
35. Why does a bitter taste often produce vomiting?
36. Is there any danger in looking "cross-eyed" for fun?
37. Should school-room desks face a window?
38. Why do we look at a person to whom we are listening attentively?
39. Do we really feel with our fingers?
40. Is the eye a perfect sphere? (See Fig. 60.)
41. How often do we wink?
42. Why is the interior of a telescope or microscope often painted black?
43. What is "the apple of the eye?"
44. What form of glasses do old people require?

45. Should we ever wash our ears with cold water?
46. What is the object of the winding passages in the nose?
47. Can a smoker tell in the dark, whether or not his cigar is lighted?
48. Will a nerve re-unite after it has been cut?
49. Will the sight give us an idea of solidity? *
50. Why can a skillful surgeon determine the condition of the brain and other internal organs by examining the interior of the eye? †
51. Is there any truth in the idea that the image of the murderer can be seen in the eye of the dead victim?

* "A case occurred a few years ago, in London, where a friend of my own performed an operation upon a young woman who had been born blind, and, though an attempt had been made in early years to cure her, it had failed. She was able just to distinguish large objects, the general shadow, as it were, without any distinct perception of form, and to distinguish light from darkness. She could work well with her needle by the touch, and could use her scissors and bodkin and other implements by the training of her hand, so to speak, alone. Well, my friend happened to see her, and he examined her eyes, and told her that he thought he could get her sight restored; at any rate, it was worth a trial. The operation succeeded; and, being a man of intelligence and quite aware of the interest of such a case, he carefully studied and observed it; and he completely confirmed all that had been previously laid down by the experience of similar cases. There was one little incident which will give you an idea of the education which is required for what you would suppose is a thing perfectly simple and obvious. She could not distinguish by sight the things that she was perfectly familiar with by the touch, at least when they were first presented to her eyes. She could not recognize even a pair of scissors. Now, you would have supposed that a pair of scissors, of all things in the world, having been continually used by her, and their form having become perfectly familiar to her hands, would have been most readily recognized by her sight; and yet she did not know what they were; she had not an idea until she was told, and then she laughed, as she said, at her own stupidity. No stupidity at all: she had never learned it, and it was one of those things which she could not know without learning. One of the earliest cases of this kind was related by the celebrated Cheselden, a surgeon of the early part of last century. Cheselden relates how a youth just in this condition had been accustomed to play with a cat and a dog; but for some time after he attained his sight he never could tell which was which, and used to be continually making mistakes. One day, being rather ashamed of himself for having called the cat the dog, he took up the cat in his arms and looked at her very attentively for some time, stroking her all the while; and in this way he associated the impression derived from the touch, and made himself master (so to speak) of the whole idea of the animal. He then put the cat down, saying, 'Now, puss, I shall know you another time.'"—CARPENTER.

† This is done by means of an instrument called the ophthalmoscope. Light is thrown into the eye with a concave mirror, and the interior of the organ examined with a lens.

C O N C L U S I O N .

VALUE of Health.—The body is the instrument which the mind uses. If it be dulled or nicked, the effect of the best labor will be impaired. The grandest gifts of mind or fortune are comparatively valueless unless there be a healthy body to use and enjoy them. The beggar, sturdy and brave with his out-door life, is really happier than the rich man in his palace with the gout to twinge him amid his pleasures. The day has gone by when delicacy was considered an element of beauty. Weakness is timid and irresolute; strength is full of force and energy. Weakness walks or creeps; strength speeds the race, wins the goal, and rejoices in the victory.

False Ideas of Disease.—It was formerly supposed that diseases were caused by evil spirits, who entered the body and deranged its action. Incantations, spells, etc., were resorted to in order to drive them out. By others, disease was thought to come arbitrarily, or as a special visitation of an over-ruling power. Hence, it was to be removed by fasting and prayer. Modern science teaches us that disease is not a thing, but a state. When our food is properly assimilated, the waste matter promptly excreted,

and all the organs work in harmony, we are well; when any derangement of these functions occurs, we are sick. Sickness is discord, as health is concord. If we abuse or misuse any instrument, we impair its ability to produce a perfect harmony. A suffering body is simply the penalty of violated law.

Prevention of Disease.—Doubtless a large proportion of the ills which now afflict and rob us of so much time and pleasure might easily be avoided. A proper knowledge and observance of hygienic laws would greatly lessen the number of such diseases as consumption, catarrh, gout, rheumatism, dyspepsia, scrofula, etc. There are parts of England where one-half the children die before they are five years old. Every physiologist knows that at least nine-tenths of these lives could be saved by an observance of the simple laws of health. Professor Bennet, in a lecture at Edinburgh, estimated that 100,000 persons die annually in that country from causes easily preventable.

With the advance of science, the causes of many diseases have been determined. Vaccination has been found to prevent or mitigate the ravages of small-pox. Scurvy, formerly so fatal among sailors that it was deemed "a mysterious infliction of Divine Justice against which man strives in vain," is now entirely avoided by the use of vegetables or lime-juice. Cholera, whose approach still strikes dread, and for which there is no known specific, is but the penalty for filthy streets, bad drainage, and over-crowded tenements, and may be controlled, if not prevented, by suitable sanitary measures. It was, no doubt, the intention that we should wear out by the general decay of all the organs, rather than by the giving out of any single

part, and that all should work together harmoniously until the vital force is exhausted.

Cure of Disease.—The first step in the cure of any disease is to obey the law of health which has been violated. If medicine be taken, it is not to destroy the disease, since that is not a thing to be destroyed, but to hold the deranged action in check while nature repairs the injury, and again brings the system into harmonious movement. This tendency of nature is our chief reliance. The best physicians are coming to have diminished confidence in medicine itself, and to place greater dependence upon sanitary and hygienic measures, and the efforts which nature always makes to repair injuries and soothe disordered action. They endeavor only to give her a fair chance, and sometimes to assist her by the intelligent employment of proper medicines. The indiscriminate use of patent nostrums and sovereign remedies of whose constituents we know nothing, and by which powerful drugs are imbibed at hap-hazard, cannot be too greatly deprecated.* When one needs medicine, he needs also a competent physician to advise its use.

Death and Decay.—By a mystery we cannot understand, life is linked with death, and out of the decay of our bodies they, day by day, spring afresh. At last the vital force which has held death and decay in bondage, and compelled them to minister to our growth, and serve

* A traveler in Africa states that he was surprised and delighted to find in the possession of the chief medicine man of one of the interior tribes a carefully preserved copy of the New York *Tribune*. On inquiry, he found that it was exceedingly valuable, as a minute fragment of it either rubbed on the outside or taken inwardly was a sovereign remedy for as long a list of diseases as ever graced the advertisement of an American pain-killer. The mania which some people possess for tipping with patent medicines is no more sensible than the trust of the poor savage in a New York daily.

the needs of our life, faints and yields the struggle. These powers which have so long time been our servants, gather about our dying couch, and their last offices usher us into the new life and the grander possibilities of the world to come. This last birth, we who see the fading, not the dawning life, call death.

“ O Father ! grant Thy love divine,
To make these mystic temples Thine.
When wasting age and wearying strife
Have sapp'd the leaning walls of life ;
When darkness gathers over all,
And the last tottering pillars fall,
Take the poor dust Thy mercy warms,
And mould it into heavenly forms.”

HOLMES.

APPENDIX.



H I N T S

A B O U T

THE SICK-ROOM.

A SICK-ROOM should be the lightest and cheeriest in the house. A small, close, dark bedroom or a recess is bad enough for one in health, but unendurable for a sick person. In a case of fever, and in many acute diseases, it should be remote from the noise of the family; but when one is recovering from an accident, and in all attacks where quiet is not needed, the patient may be where he can amuse himself by watching the movements of the household, or looking out upon the street.

The ventilation must be thorough. Bad air will poison the sick and the well alike. A fireplace is, therefore, desirable. Windows should open easily. By carefully protecting the patient with extra blankets, the room may be frequently aired. If there be no direct draught, much may be done to change the air, by simply swinging an outer door to and fro many times.

A bare floor, with strips of carpet here and there to deaden noise, is cleanest, and keeps the air freest from dust. Cane-bottomed chairs are preferable to upholstered ones. All unnecessary furniture should be removed out of the way. A straw bed or a mattress is better than feathers. The bed-hangings, lace curtains, etc., should be taken down. Creaking hinges should be oiled. Sperm candles are better than kerosene lamps.

Never whisper in a sick-room. All necessary conversation should be carried on in the usual tone of voice. Do not call a physician

unnecessarily, but if one be employed *obey his directions implicitly*. Never give nostrums over-officious friends may suggest. Do not allow visitors to see the patient, except it be necessary. Never bustle about the room, nor go on tip-toe, but move in a quiet, ordinary way. Do not keep the bottles in the continued sight of the sick person. Never let drinking-water stand in the room, as it will absorb noxious gases. Do not raise the patient's head to drink, but have a cup with a spout, or use a bent tube, or even a straw. Do not tempt the appetite when it craves no food. Bathe frequently, but let the physician prescribe the method. Give written directions to the watchers. Have all medicines carefully marked. Remove all soiled clothing, etc., at once from the room. Change the linen much oftener than in health. When you wish to change the sheets, and the patient is unable to rise, roll the under sheet tightly lengthwise to the middle of the bed ; put on the clean sheet, with half its width folded up, closely to the other roll ; lift the patient on to the newly-made part, remove the soiled sheet, and then spread out the clean one.

DISINFECTANTS.

An excellent disinfectant may be made by dissolving in a pail of water either of the following : (1), a quarter of a pound of sulphate of zinc and two ounces of common salt, for each gallon of water ; (2), a pound and a half of copperas for each gallon of water. Towels, bed-linen, handkerchiefs, etc., should be soaked at least an hour, in a solution of the first kind, and then be boiled, before washing. Vaults, drains, vessels used in the sick-room, etc., should be disinfected by a solution of the second kind ; chloride of lime may also be used for the same purpose. Rooms, furniture, and articles that cannot be treated with the solution of the first kind, should be thoroughly fumigated with burning sulphur.

WHAT TO DO TILL THE DOCTOR COMES.

Burns.—When a person's clothes catch fire, quickly lay him on the ground, wrap him in a coat, mat, shawl, carpet, or in his own clothes, as best you can to extinguish the fire. Pour on plenty of water till the half-burned clothing is cooled. Then carry the suf-

ferer to a warm room, lay him on a table or a carpeted floor, and with a sharp knife or scissors remove his clothing.

The treatment of a burn consists in protecting from the air.* Dress the wound with carbolic acid salve or cotton-battening, or dredge with flour. Wrap a dry bandage upon the outside. Then remove the patient to a bed and warmly cover.† An excellent remedy is to apply soft cloths kept wet with sweet oil, or *cold water which contains all the "cooking soda" that it will dissolve*. Apply cold water to a small burn till the smart ceases, and then cover with ointment. Do not remove the dressings until they become stiff and irritating; then take them from a part at a time; dress and cover again quickly.

Cuts, Wounds, etc.—The method of stopping the bleeding has been described on page 126. If an artery is severed, a physician should be called at once. If the bleeding is not profuse, apply cold water until it ceases, dry the skin, draw the edges of the wound together, and secure them by strips of adhesive plaster. Protect with an outer bandage. This dressing should remain for several days. In the meantime wet it frequently with cold water to subdue inflammation. When suppuration begins, wash occasionally with tepid water and Castile soap.

Bleeding from the Nose is rarely dangerous, and often beneficial. When it becomes necessary to stop it, sit upright and compress the nostrils between the thumb and forefinger, or with the thumb press upward upon the upper lip. A piece of ice, a snow-ball, or a compress wet with cold water may be applied to the back of the neck.

A Sprain is often more painful and dangerous than a dislocation. Wrap the injured part in flannels wrung out of hot water, and cover with a dry bandage, or, better, with oiled silk. Liniments and stimulating applications are injurious in the first stages, but useful when the inflammation is subdued. *Do not let the limb hang down.*

* It is a great mistake to suppose that salves will "draw out the fire" of a burn, or heal a bruise or cut. The vital force must unite the divided tissue by the deposit of material, and the formation of new cells.

† If a burn be near a joint or on the face, even if small, let a doctor see it, and do not be in any hurry about having it healed. Remember that with all the care and skill which can be used, contractions will sometimes take place. The danger to life from a burn or scald is not in proportion to its severity, but to its extent—that is, a small part, such as a hand or a foot or a face, may be burned so deeply as to cripple it for life, and yet not much endanger the general health; but a slight amount of burning, a mere scorching, over two-thirds of the body, may prove fatal.—HOPE.

It must be kept quiet, even after all pain has ceased. If used too quickly, dangerous consequences may ensue.

Diarrhea, Cholera Infantum, etc., are often caused by eating indigestible food or checking of the perspiration; but more frequently by peculiar conditions of the atmosphere, especially in large cities. If the limbs are cold, give a hot bath, and rub thoroughly. *If possible, go to bed and lie quietly on the back. Rest is better than medicine.* If there be pain, apply repeatedly to the abdomen flannels wrung out of hot water. If medicine is needed, take fifteen drops of peppermint and thirty of paregoric in a wine-glass of warm water; or an adult may take twenty drops of spirits of camphor and thirty to forty drops of laudanum. Laudanum should never be given to an infant, except by a physician's order. Eat no fruit, vegetables, pastry, or pork. If much thirst exist, give small pieces of ice, or cold tea or toast-water.

Croup.—Send at once for a doctor. Induce vomiting by syrup of ipecac or mustard and water. Put the feet in a hot bath. Apply hot fomentations rapidly renewed to the chest and throat.

Sore Throat.—Wrap the neck in a wet bandage, and cover with red flannel or a woolen stocking. Gargle the throat frequently with a solution of a tea-spoonful of salt in a pint of water, or thirty grains of chlorate of potash in a wine-glass of water.

Fits, Apoplexy, Epilepsy, etc.—Loosen the clothing and raise the head and shoulders, but do not bend the head forward on the neck. Apply cold to the head, and heat to the feet. Follow with an emetic. In a child, a full hot bath is excellent. When there are convulsions, prevent the patient from injuring himself; especially put something in his mouth to keep him from biting his tongue.

Toothache and Earache.—Insert in the hollow tooth, or in the ear, cotton wet with laudanum, spirits of camphor, or chloroform. When the nerve is exposed, wet it with creosote or carbolic acid. Hot cloths or a hot brick wrapped in cloth and held to the face will often relieve the toothache. In a similar manner treat the ear, wetting the cloth in hot water, and letting the vapor pass into the ear.

Choking.—Ordinarily a smart blow between the shoulders, causing a compression of the chest and a sudden expulsion of the air from the lungs, will throw out the substance. If the person can swallow, and the object be small, give plenty of bread or potato, and water to wash it down. Press upon the tongue with a spoon, when, perhaps, you may see the offending body, and draw it out with

a blunt pair of scissors. If neither of these remedies avail, give an emetic of syrup of ipecac or mustard and warm water.

Frost Bites are frequently so sudden that one is not aware when they occur. In Canada it is not uncommon for persons meeting in the street to say, "Mind, sir, your nose looks whitish." The blood cools and runs slowly, and the blood-vessels become choked and swollen. *Keep from the heat.* Rub the part quickly with snow, if necessary for hours, till the natural color is restored. If one is benumbed with cold, take him into a cold room, remove the wet clothes, rub the body dry, cover with blankets, and give a little warm tea or weak brandy and water. On recovering, let him be brought to a fire gradually.*

Fever, and many acute diseases, are often preceded by a loss of appetite, headache, shivering, "pains in the bones," indisposition to work, etc. In such cases, sponge with tepid water, and rub the body till all aglow. Go to bed, place hot bricks to the feet, take nothing but a little gruel or beef tea, and drink moderately of warm, cream-of-tartar water. If you do not feel better the next morning, call a physician. If that be impossible, take a dose of castor-oil or Epsom salt.

Sun-stroke is a sudden prostration caused by intense heat. The same effect is produced by the burning rays of the sun and the fierce fire of a furnace. When a person falls under such circumstances, place your hand on his chest. If the skin be cool and moist, it is not a sun-stroke; but if it be dry and "biting hot," there can be no mistake. Time is now precious. At once carry the sufferer to the nearest pump or hydrant, and dash cold water on the head and chest until consciousness is restored.—DR. H. C. WOOD.

To prevent sun-stroke, wear a porous hat, and in the top of it place a wet handkerchief; also drink freely of water, not ice cold, to induce abundant perspiration.

Asphyxia, or apparent death, whether produced by drowning, suffocation, bad air, or coal gas, requires very similar treatment. Send at once for blankets, dry clothing, and a physician. Treat the sufferer upon the spot, if the weather be not too unfavorable.

i. Loosen the clothing about the neck and chest.

* If you are caught in a snow-storm, look for a snow-bank in the lee of a hill, or a wood out of the wind, or a hollow in the plain filled with snow. Scrape out a hole big enough to creep into, and the drifting snow will keep you warm. Men and animals have been preserved after days of such imprisonment. Remember that if you give way to sleep in the open field, you will never awake.

2. Turn the patient on his face, open the mouth, draw out the tongue, and cleanse the nostrils, so as to clear the air-passages.

3. Place the patient on his back, grasp his arms firmly above the elbows, and pull them gently upward until they meet over the head, in order to draw air into the lungs. Then bring the arms back by the side, to expel the air. Repeat the process about fifteen times per minute. Alternate pressure upon the chest, and blowing air into the mouth through a quill or with a pair of bellows, may aid your efforts. Excite the nostrils with snuff or smelling salts, or by passing hartshorn under the nose. Do not cease effort while there is hope. Life has been restored after five hours of suspended animation.

4. When respiration is established, wrap the patient in dry, warm clothes, and rub the limbs under the blankets or over the dry clothing energetically *toward the heart*. Apply heated flannels, bottles of hot water, etc., to the limbs, and mustard plasters* to the chest.

Foreign Bodies in the Ear.—Insects may be killed by dropping a little sweet oil into the ear. Beans, peas, matches, etc., may generally be removed by *cautiously* syringing the ear out with tepid water. Do not use much force lest the tympanum be injured. If this fail, dry the ear, stick the end of a little linen swab into thick glue, let the patient lie on one side, put this into the ear until it touches the substance, keep it there three-quarters of an hour while it hardens, and then draw them all out together. Be careful that the glue does not touch the skin at any point, and that you are at work upon the right ear. Children often deceive one as to the ear which is affected.

Foreign Bodies in the Nose, such as beans, cherry-pits, etc., may be frequently removed by closing the opposite nostril, and then blowing into the child's mouth forcibly. The air, unable to escape except through the other nostril, will sweep the obstruction before it.

* The best mustard poultice is the paper plaster now sold by every druggist. It is always ready, and can be carried by a traveler. It has only to be dipped in water, and applied at once.

ANTIDOTES TO POISONS.

Acids: *Nitric* (aqua fortis), *hydrochloric* (muriatic), *sulphuric* (oil of vitriol), *oxalic*, etc.—Drink a little water to weaken the acid, or, still better, take strong soap-suds. Stir some magnesia in water, and drink freely. If the magnesia be not at hand, use chalk, soda, lime, whiting, soap, or even knock a piece of plaster from the wall, and scraping off the white outside coat pound it fine, mix with milk or water, and drink at once. Follow with warm water, or flax-seed tea.

Alkalies: *Potash*, *soda*, *ley*, *ammonia* (hartshorn).—Drink weak vinegar or lemon juice. Follow with castor or linseed oil, or thick cream.

Antimony: *Antimonial wine*, *tartar emetic*, etc.—Drink strong, green tea, and in the mean time chew the dry leaves. The direct antidote is a solution of nut-gall or oak-bark.

Arsenic: *Cobalt*, *Scheele's green*, *fly-powder*, *ratsbane*, etc.—Give plenty of milk, whites of eggs, or induce vomiting by mustard and warm water, or even soap-suds.

Bite of a Snake or a Mad Dog.—Tie a bandage above the wound, if on a limb. Wash the bite thoroughly, and, if possible, let the person suck it strongly. Rub some lunar caustic or potash in the wound, or heat the point of a small poker or a steel-sharpener white hot, and press it into the bite for a moment. It will scarcely cause pain, and will be effectual in arresting the absorption of the poison, unless a vein has been struck. Whiskey drank freely is also an excellent remedy.

Copper: *Sulphate of copper* (blue vitriol), *acetate of copper* (verdigris).—Take whites of eggs or soda. Use milk freely.

Laudanum: *Opium*, *paregoric*, *soothing cordial*, *soothing syrup*, etc.—Give an emetic at once of syrup of ipecac or mustard and warm water, etc. After vomiting, use strong coffee freely. *Keep the patient awake* by pinching, pulling the hair, walking about, dashing water in the face, and any expedient possible.

Lead: *White lead*, *acetate of lead* (sugar of lead), *red lead*.—Give an emetic of syrup of ipecac, or mustard and warm water, or salt and water. Follow with a dose of Epsom salt.

Matches: *Phosphorus*.—Give magnesia, chalk, whiting, or even flour in water, and follow with mucilaginous drinks.

Mercury. *Calomel*, *chloride of mercury* (corrosive sublimate, bug).

poison), red precipitate.—Drink milk copiously. Take the whites of eggs, or even stir flour in water, and use freely.

Nitrate of Silver (lunar caustic).—Give salt and water, and follow with castor-oil.

Nitrate of Potash (saltpetre, nitre).—Give mustard and warm water, or syrup of ipecac. Follow with flour and water, and cream or sweet-oil.

Prussic Acid (oil of bitter almonds), *cyanide of potassium*.—Take a tea-spoonful of hartshorn in a pint of water. Apply smelling salts to the nose, and dash cold water in the face.

Sting of an Insect.—Apply a little hartshorn or spirits of camphor, or soda moistened with water, or a paste of clean earth and saliva.

Sulphate of Iron (green vitriol).—Give syrup of ipecac, or mustard and warm water, or any convenient emetic; then magnesia and water.

QUESTIONS FOR CLASS USE.

The questions include the notes. The figures refer to the pages.

INTRODUCTION.

ILLUSTRATE the value of physiological knowledge. Why should physiology be studied in youth? When are our habits formed? How do habits help us? Why should children prize the lessons of experience? How does Nature punish a violation of her laws? Name some of Nature's laws. What is the penalty of their violation? Name some bad habits and their punishments. Some good habits and their rewards. How do the young ruin their health? Compare one's constitution with a deposit in the bank. Can one in youth lay up health as he can money for middle or old age? (See *Conclusion*.) Is not the preservation of one's health a moral duty? What is suicide?

THE SKELETON.

How many bones are there in the body? Is the number fixed? Is the length of the different bones proportional? What is an organ? A function? Name the three uses of the bones. Why do the bones have such different shapes?

20. Why are certain bones hollow? Round? Illustrate. What is

the composition of bone? How does it vary? How can you remove the mineral matter? The animal matter? Why is a burned bone white and porous? What is the use of each of the constituents of a bone? What food do dogs find in bones? What is "bone black?"

21. What is ossification? Why are not the bones of children as easily broken as those of aged persons? Why do they unite so much quicker? What are the fontanelles?

22. Describe the structure of a bone. What is the object of the filling? Why does the amount vary in different parts of a bone? What is the appearance of a bone seen through a microscope? What is the periosteum? Is a bone once removed ever restored?

23. What are the lacunæ? The Haversian canals? Why so called? How do bones grow? Illustrate. How does a broken bone heal? How rapidly is bone produced? Illustrate.

24. Objects of "splints?" Describe how a joint is packed. Lubricated. How are the bones tied together? Name the three general divisions of the bones. What is a tissue? Illustrate.

25. What is the object of the skull? Which bone is movable? How is the lower jaw hinged?

26. Describe the construction of the skull. What is a suture? Tell how the peculiar form and structure of the skull adapt it for its use. Illustrate the impenetrability of the skull. Describe the experiment of the balls. What does it show?

27. What two cavities are in the trunk? Name its principal bones. Describe the spine. What is the object of the processes? Of the pads? Why is a man shorter at night than in the morning?

28. Describe the perfection of the spine. The articulation of the skull with the spine. Why is the atlas so called?

29. Describe the ribs. What is the natural form of the chest? Why is the thorax or chest made in separate pieces?

30. How do the hip-bones give solidity? What two sets of limbs branch from the trunk? State their mutual resemblance.

31. Name the bones of the shoulder. Describe the collar-bone. The shoulder-blade. Name the bones of the arm.

32. Describe the shoulder-joint. The elbow-joint. The wrist.

33. Name the bones of the hand. The fingers. Describe their articulations. What gives the thumb its freedom of motion? In what lies the perfection of the hand?

34. Describe the hip-joint. What gives the upper limbs more freedom of motion than the lower? How does the pressure of the air aid us in walking? Illustrate. How do the gestures of the hand enforce our ideas and feelings?

35. Name the bones of the lower limbs. Describe the knee-joint. The patella. What is the use of the fibula? Name the bones of the foot. What is the use of the arch of the foot? What makes the step elastic?

36. Describe the action of the foot as we step. What are the causes of deformed feet? What is the natural position of the big toe? Did you ever see one lying in a straight line with the foot, as shown in statuary and paintings? How should we have our boots and shoes made? What are the effects of high heels? Of narrow heels? Of narrow toes? Of tight-laced boots? Of thin soles?

37. What are the rickets? Cause of this disease? Cure? Causes of spinal curvature? Cure? What is a felon? Cure? Cause of bow-legs? Cure? Is there any provision for remedying defects in the body? Name one. What is the correct position in sitting at one's desk? Is there any necessity for walking and sitting erect? Describe the bad effects of a stooping position.

38. What is a sprain? Why does it need special care? What is a dislocation?



THE MUSCLES.

43. **WHAT** is the use of the skeleton? How is it concealed? Why is it the image of death? What are the muscles? How many are there? How are they arranged? What property have they?

44. Where is the biceps? The triceps? How do the muscles move the limbs? Illustrate. What is the cause of squinting? Cure? (See page 193.) Name and define the two kinds of muscles. Illustrate each. What is the structure of a muscle? Of what is a fibril itself composed?

45. How does the peculiar construction of the muscle confer strength? Describe the tendons. What is their use? Illustrate the advantages of this mode of attachment.

46. What two special arrangements of the tendons in the hand? Their use? How is the rotary motion of the eye obtained? What is a lever? Describe the three classes of levers. Illustrate each.

47. Name the muscles of the eye. Describe their action. Describe the head as a lever. What part of the body illustrates the three kinds of levers?

48. Give an illustration of the second class of levers. The third class. Why is the tendon of Achilles so named? What is the advantage of the third class of levers?

49. Why used in the hand? What class of lever is the lower jaw? What advantages are gained by the enlargement of the bones at the joints? Illustrate.

50. How do we stand erect? Is it an involuntary act? Why cannot a child walk at once, as many young animals do? Why can we not hold up the head easily when we walk on "all fours?" Why cannot an animal stand erect as man does? Describe the process of walking.

51. Show that walking is a process of falling. Describe the process of running. What causes the swinging of the hand in walking? Why are we shorter when walking? Why does a person when lost often go in a circle? What is the muscular sense?

52. Its value? Value of exercise? Danger of violent exercise? For what purpose should we exercise? Should exercise be in the open air?

53. What is the rule for exercise? Is a young person excusable, who leads a sedentary life, and yet takes no daily out-door exercise? What will be nature's penalty for such a violation of her law? Will a postponement of the penalty show that we have escaped it? Ought a scholar to study during the time of recess? Will a promenade in the vitiated air of the school-room furnish suitable exercise? What is the best time for taking exercise? Who can exercise before breakfast? What are the advantages of the different kinds of exercise? Should we not walk more?

54. State some of the wonders of the muscles. What is the St. Vitus's Dance? Cure?

55. What is the locked-jaw? Causes? The gout? Cause? Cure? The rheumatism? Its two forms? Peculiarity of the acute?

56. Danger? Is there any particular mode of treating it? What is the lumbago? Give instances. What is a ganglion? Its cure? A bursa?



THE SKIN.

61. **WHAT** are the uses of the skin? Describe its adaptation to its place. What is its function as an organ? Describe the structure of the skin. The sensitiveness of the cutis. The insensitiveness of the cuticle.

62. How is the skin constantly changing? The shape and number of the cells? Value of the cuticle?

63. What is the complexion? Its cause? Why is a scar white? What is the cause of "tanning?" What are freckles? Albinos? Describe the action of the sun on the skin. Why are the hairs and the nails spoken of under the head of the skin?

64. Uses of the hair? Its structure? What is the hair-bulb? What is it called? How does a hair grow? When can it be restored, if destroyed? What is the danger of hair-dyes? Are they of any real value?

65. How can the hair stand on end? How do horses move their skin? Is there any feeling in a hair? Illustrate the indestructibility of the hair. The uses of the nails.

66. How do the nails grow? What is the mucous membrane? Its composition? The connective tissue? Why so called?

67. What use does it subserve? What is its character? How does the fat exist in the body? Its uses?

68. Where is there no fat? Why are the teeth spoken of in connection with the mucous membrane? Name and describe the four kinds of teeth. What are the milk-teeth? Describe them.

69. What teeth appear first? When do the permanent teeth appear? Describe their growth. Which one comes first? Last?

70. Describe the structure of the teeth. How are the teeth fitted in the jaw? Why do the teeth decay?

71. What care should be taken of the teeth? What caution should be observed? What are the oil glands?

72. Use of this secretion? What are the perspiratory glands? State their number. Their total length? What are the "pores" of the skin? What is the perspiration?

73. What is the constitution of the perspiration? Illustrate its value. Name the three uses of the skin. Illustrate the absorbing power of the skin. Why are cosmetics and hair-dyes injurious?

74. What relation exists between the skin and the lungs? When is the best time for a bath? Why? Value of friction?

75. Should a bath be taken just before or after a meal? Is soap beneficial? What is the "reaction?" Explain its invigorating influence. How is it secured? General effect of a cold bath? Of a warm bath? If we feel chilly and depressed after a bath, what is the teaching? Describe the Russian vapor bath.

76. Why is the sea-bath so stimulating? How long should one remain in any bath? How does clothing keep us warm? Explain the use of linen as an article of clothing. Cotton. Woolen.

Flannel. How can we best protect ourselves against the changes of our climate?

77. What colored clothing is best adapted for all seasons? Value of the nap? Furs? Thick *vs.* thin clothing? Should we wear thick clothing during the day, and in the evening put on thin clothing? Can children endure exposure better than grown persons? What is the erysipelas? How relieved?

78. The dropsy? Corns? Cause? Cure? In-growing nails? Cure? Warts? Cure? Chilblain?

79. Cause? Preventive? Wens? Cure?



RESPIRATION AND THE VOICE.

83. NAME the organs of respiration and the voice. Describe the larynx. The epiglottis. The oesophagus. What is meant by food "going the wrong way?"

84. Describe the vocal cords. Their use. How is sound produced?

85. How are the higher tones of the voice produced? The lower? Upon what does loudness depend? A falsetto voice? What is the cause of the voice "changing?" What is speech? Vocalization? Could a person talk without his tongue? Illustrate. How are talking-machines made?

86. How is *a* formed by the voice? What is *h*? Difference between a sigh and a groan? What vowel sounds are made in laughing? Does whistling depend on the voice?

87. Tell how the various consonants are formed. What are the labials? The dentals? The linguals? What vowels does a child pronounce first? Describe the wind-pipe. The bronchi. The bronchial tubes. Why is the trachea so called?

88. Describe the structure of the lungs. What are the lungs of slaughtered animals called? Why will a piece of the lungs float on water?

89. Name the wrappings of the lungs. Describe the pleura. How is friction prevented? What are the cilia? What is their use? What two acts constitute respiration? In what two ways may the position of the ribs change the capacity of the chest?

90. Describe the process of respiration. Expiration. How often

do we breathe? Describe the diaphragm. What is sighing? Coughing? Sneezing? Snoring?

91. Laughing? Crying? Hiccough? Yawning? Its value? What is meant by the breathing capacity? How does it vary? How much, in addition, can the lungs expel forcibly? How much of the breathing capacity is only available through practice? Value of this extra supply? Can we expel all the air from our lungs?

92. Value of this constant supply? How constant is the need of air? What is the vital element of the air? Describe the action of the oxygen in our lungs. What does the blood give up? Gain? How can this be tested? What are the constituents of the air? What are the peculiar properties and uses of each?

93. What is the condition of the air we exhale? Which is the most dangerous constituent? Describe the evil effects of re-breathing the air. For what is the "Black Hole of Calcutta" noted? Give other illustrations of the dangers of bad air. What is meant by the germs of disease floating in the air.

94. Describe the need of ventilation. Will a single breath pollute the air? What is the influence of a fire or a light? Of a hot stove? When is the ventilation perfect? What diseases are largely owing to bad air? Should the windows and doors be tightly closed if we have no other means of ventilation? Is not a draught of air dangerous? How can we prevent this, and yet secure fresh air? Must pure air necessarily be cold air?

95. Are school-rooms properly ventilated? What is the effect? Are churches? Are our bed-rooms? Can we, at night, breathe anything but night air? Is the night air out-of-doors injurious? *Ans.* It is, in times and places of malaria, and should be carefully avoided, even at the risk of bad air in-doors.

96. Describe some of the wonders of respiration. How is constriction of the lungs produced? When may clothing be considered tight?

97. What are the dangers of tight-lacing? Which would make the stronger, more vigorous, and longer-lived person, the form shown in *A* or *B*, Fig. 33? Is it safe to run any risk in this dangerous direction? What is the bronchitis? Pleurisy? Pneumonia?

98. Consumption? What is one great cause of this disease? How may a constitutional tendency to this disease be warded off in youth? *Ans.* Besides plenty of fresh air and exercise, care should be taken in the diet. Rich pastry, unripe fruit, salted meat, and acid drinks should be avoided, and a certain quantity of fat should

be eaten at each meal.—BENNETT. What is asphyxia? Describe the process for restoring such a person. (See *Appendix*.) What is the diphtheria? Its peculiarity? Danger? The croup? Its characteristics? Remedy? (See *Appendix*.)

99. Causes of stammering? How cured?



THE CIRCULATION.

105. NAME the organs of the circulation. Does the blood permeate all parts of the body? What is the average amount in each person? Its composition? The plasma? The red corpuscles? The white?

106. What is the size of a red cell? Are the shape and size uniform? Value of this? Illustrate. Are the disks permanent?

107. What substances are contained in the plasma? In what sense is the blood "liquid flesh?" What is the use of the red disks? What is the office of the oxygen in the body? Where is the blood purified?

108. What is transfusion? Give some illustrations. Is it of value? What is the cause of coagulation of the blood? Value of this property?

109. Has the fibrin any other use? What organ propels the blood? What is the location of the heart? How large is it? Put your hand over it?

110. What is the pericardium? Describe the systole? The diastole. How many chambers in the heart? What is their average size? What is meant by the right and the left heart? What are the auricles? Why so called? The ventricles?

111. What is the use of the auricles? The ventricles? Which are made the stronger?

112. Show the need of valves in the ventricles. Why are there no valves in the auricles? Draw on the board the form of the valves. Name them.

113. Describe the tricuspid valve. The bicuspid. How are these valves strengthened? What peculiarity in the attachment of these cords? Describe the semi-lunar valves. What are the arteries? Why so named?

114. What is their use? Their structure? How does their elasticity act? What is meant by a "collateral circulation?" How are

the arteries protected? Where are they located? Give a general description of the arterial system. What is the aorta? What is the pulse? On which arteries can we best feel it?

115. What is the average number of beats per minute? How and why does this vary? Why does a physician feel a patient's pulse? What are the veins? What blood do they carry? Describe the venous system. What vein does not lead toward the heart? Describe the valves of the veins. What valves of the heart do they resemble?

116. Where and how can we see the operation of these valves? What are the capillaries? What changes take place in this system? What are varicose veins?

117. Describe the circulation of the blood as seen in the web of a frog's foot. In what two portions is the general circulation divided? Who discovered the circulation of the blood? How was the discovery received? What remark did Harvey make? What does that show?

118-9. Describe the route of the blood by the diagram. 1. The lesser circulation; 2. The greater circulation. What is the velocity of the blood? How long does it require for all the blood to pass through the heart? How has this been estimated? What is the shortest route the blood can take? The longest? How long does it take the blood to make the tour of the body? How has this been estimated? What is the average temperature of the body? How much does this vary in health? *Ans.* Not more than 2° , even in the greatest extremes of temperature.—FLINT.

120. How and where is the heat of the body generated? How is it distributed? In what diseases is the variation of temperature marked? How is the temperature of the body regulated?

121. In what way does life exist through death? Is not this as true in the moral as in the physical world? What does it teach? How rapidly do our bodies change? What are the three vital organs?

122. Name some of the wonders of the heart.

123. What is the lymphatic circulation? What is the thoracic duct? The lymph? The glands?

124. What is the office of the lymphatics? What are the lacteals? Give some illustrations of the action of the lymphatics of the different organs. Should we use wall-paper having much green? What is meant by the sub-cutaneous insertion of morphine? How do hibernating animals live during the winter?

125. What is a congestion? Its cause? Blushing? Why does terror cause one to grow cold and pale?

126. How is an inflammation caused? Name its four characteristics. How may severe bleeding be stopped? How can you tell whether the blood comes from an artery or a vein? Why should you know this?

127-8. What is the scrofula? What are "kernels?" How may a scrofulous tendency of the system be counteracted? What kinds of food stimulate this disease? What is the cause of "a cold?" Why does exposure sometimes cause a cold in the head, sometimes on the lungs, and at others brings on a rheumatic attack? Why is a cold dangerous? *Ans.* It weakens the system and paves the way for other diseases. What is the theory of treating a cold? Describe the method. What is catarrh? Cause?



DIGESTION AND FOOD.

133. WHY do we need food? Why will a person starve without food? Are the current stories of people who live without food to be relied upon? How much food is needed per day by an adult in active exercise?* How much in a year? How does this amount vary?

134. Describe the body as a mould. As an eddy. What does food do for us? What does food contain? How is this force set free? What force is this? How can it be turned into muscular motion, mental vigor, etc.? Do we then draw all our power from nature? What becomes of these forces when we are done with them? Do we destroy the force we use? *Ans.* No matter has been destroyed, so far as we know, since the creation and force is equally indestructible.

135. Compare our food to a tense spring. What three kinds of

* "From experiments performed while living on an exclusive diet of bread, fish, meat, and butter, with coffee and water for drink, we have found that the entire quantity of food required during twenty-four hours, by a man in full health, and taking free exercise in the open air, is as follows:

Meat,	16 ounces, or 1.00 lbs. avoirdupois.
Bread,	19 " " 1.19 "
Butter, or fat,	3 $\frac{1}{2}$ " " 0.22 "
Water,	52 fluid oz. " 3.38 "

That is to say, rather less than two and a half pounds of solid food, and rather over three pints of liquid food."—DALTON.

food do we need? What is nitrogenous food? Name the common forms. What is the characteristic of nitrogenous food? Why called albuminous? What is carbonaceous food? Its two kinds?

136. Constituents of sugar? Where are starch and gum ranked? Why? Use of carbonaceous food? What becomes of this heat? Composition of fat? How does fat compare with sugar in producing heat? Name the other uses of the carbonaceous food. Name the mineral matters which should be contained in our food. What do you say of the abundance and necessity of water? Ought we not to exercise great care in selecting the water we drink? *

137. Will not the character of our food influence the quantity of water? What are the uses of these different minerals? Illustrate the importance of salt. Could a person live on one kind of food alone? Illustrate.

138. Describe the effect of living on lean meat. Show the necessity of a mixed diet. Illustrate. Show the need of digestion. Illustrate. What is assimilation? Describe the general plan of digestion. What did Berzelius call digestion? Why? What amount of liquid is daily secreted by the alimentary canal?

139. What is the alimentary canal? How is it lined? How does the amæba digest its food? The hydra? Define secretion. Describe the saliva. How secreted?

140. What is the amount? Its organic principle? Its use? How soon does it act? How long? What tends to check or increase the flow of saliva?

141. Describe the process of swallowing. The stomach. Its size. Its construction. What is the peristaltic movement? The pylorus? For what does this open? What is the gastric juice?

142. How abundant is it? To what is its acidity due? What organic principle does it contain? How is its flow influenced? What is its use? Appearance of the food as it passes through the

* Water, which has passed through lead-pipes, is apt to contain salts of that metal, and is therefore open to suspicion. (See *Chemistry*, page 160.) Metallic-lined ice-pitchers, galvanized-iron reservoirs, and many soda-water fountains, are liable to the same objection. There are also organic impurities in water equally dangerous. (See *Chemistry*, page 60.) River-water often disseminates the germs of typhoid fever and other diseases just as the air scatters the seeds of smallpox and scarlet fever (page 93). Thus the great outbreak of cholera in the east of London, in 1866, was traced to the contamination of the River Lea, which furnished the supply of water to that part of the city. The surface water frequently flows into a well carrying organic matter to poison its contents. Wells sometimes receive underground the drainage from grave-yards, manufactories, cess-pools, swamps, etc., all of which render the water unfit for use.

pylorus? How is pepsin prepared? Why is not the stomach itself digested? What is the construction of the intestines?

143. How are the intestines divided? What is the duodenum? Why so called? What juices secreted here? What is the bile? Describe the liver. What is its weight? Its construction? *Ans.* It consists of a mass of polyhedral cells only $\frac{1}{100}$ to $\frac{1}{500}$ of an inch in diameter, filling a mesh of capillaries. The capillaries carry the blood to and fro, and the cells secrete the bile. What is the cyst? What does the liver secrete from the blood beside the bile? Is the bile necessary to life? Illustrate. What is its use?

144. What is the pancreatic juice? Its organic principle? Its use? Appearance of the food when it leaves the duodenum? Describe the small intestine.

145. What is absorption? In what two ways is the food absorbed? Where does the process commence? How long does it last? Describe the lacteals. Of what general system do they form a part? What do they absorb? Where do they carry the food? What do the veins absorb? Where do they carry the food? How is it modified?

146. Describe the complexity of the process of digestion. What length of time required for digestion in the stomach? May not food which requires little time in the stomach need more in the other organs, and *vice versa?* Tell the story of Alexis St. Martin.

147. What time was required to digest an ordinary meal? Apples? Eggs, raw and cooked? Roast beef? Pork? Which is the king of the meats? What is the nutritive value of mutton? Lamb? How should it be cooked? Objection to pork? What is the trichina? Should ham ever be eaten raw? Value of fish? Oysters? Milk? Cheese? Eggs?

148. Bread? Brown bread? Are warm biscuit and bread healthy? Nutritive value of corn? The potato? Of ripe fruits? Of coffee?

149. To what is its stimulating property due? Its influence on the system? When should it be discarded? Should children use any stimulants? Effects of tea? Influence of strong tea?* What is the active principle of tea? Nutritive value of chocolate? What is its active principle? Story of Linnæus? How should tea be made? What is the active principle of tobacco?

150. Effects of tobacco? Are these immediate? Effects upon

* The tannin in tea is shown when a drop falls on a knife-blade. The black spot is a tannate of iron—a compound of the acid in the tea and the metal.

youth? Give *all* the reasons why a young man should not learn to use tobacco. What is the active principle of all fermented liquors? Does alcohol fortify against the cold? What is its general influence? What is the effect of cooking food? What precaution in boiling meat? In roasting? Object of this high temperature?

151. What precaution in making soup? Why is frying an unhealthy mode of cooking? State the five evil results of rapid eating. What disease grows out of it? If one is compelled to eat a meal rapidly, as at a railroad station, what should he take? Why? Why does a child need more food proportionately than an old person? State the relation of waste to repair in youth, in middle, and in old age. What kind and quantity of food does a sedentary occupation require? What caution should students, who have been accustomed to manual labor, observe?

152. Must a student starve himself? Is there not danger of overeating? Would not an occasional abstinence from a meal be beneficial? Do not most people eat more than is for their good? How should the season regulate our diet?* The climate? Illustrate. What does a natural appetite indicate? How are we to judge between a natural and an artificial longing? What does the craving of childhood for sugar indicate?† What is the effect upon the circulation of taking food? Should we labor or study just before or after a meal? Why not?

153. What time should intervene between our meals? Is "lunch-

* Dr. Hayes, the arctic explorer, says, that the daily ration of the Esquimaux is from twelve to fifteen pounds of meat, one-third being fat. On one occasion he saw a man eat ten pounds of walrus flesh and blubber at a single meal. (See *Chemistry*, page 228.) The low temperature had a remarkable effect on the members of his own party, and some of them were in the habit of drinking the contents of the oil-kettle with evident relish. Other travellers narrate the most incredible stories of the voracity of the inhabitants of arctic regions. Saritcheff, a Russian admiral, tells of a man, who in his presence ate, at a meal, a mess of twenty-eight pounds of boiled rice and butter, although he had already partaken of his breakfast. Capt. Cochrane further adds, in narrating this statement, that he has himself seen three of the savages consume a reindeer at a sitting.

† It does not follow from this, however, that the free use of sugar in its separate form is desirable. The ordinary articles of vegetable food contain sugar (or starch, which in the body is converted into sugar), in large proportion; and there is good reason to believe that in its naturally-combined form it is both more easily digested, and more available for the purposes of nutrition, than when crystallized. The ordinary sugar of commerce, moreover, derived from the sugar-cane, is not capable of being directly applied to physiological purposes. Cane-sugar is converted within the body into another kind of sugar, identical with that derived from the grape, before it can enter into the circuit of the vital changes.

ing" a healthy practice? Eating just before retiring? Why should care be banished from the table? Will a regular routine of food be beneficial?

154. Describe some of the wonders of digestion. What are the principal causes of dyspepsia? How may we avoid that disease?

155. What are the mumps? What care should be taken?



THE NERVOUS SYSTEM.

159. What are the organs of the nervous system? What is the general use of this system? How does it distinguish animals from plants? What are the vegetative functions? What is the gray matter? Its use? The white matter? Its use?

161. Describe the brain. What is its office? Its size? How does it vary? Illustrate. Name its two divisions. Describe the cerebrum. The convolutions. The membranes which bind the brain together. What do you say of the quantity of blood which goes to the brain? What does it show?

162. What do the convolutions indicate? What is the use of the two halves of the brain? What theories have been advanced concerning it?

163. What is the effect of removing the cerebrum? Describe the cerebellum.

164. What is the arbor vitæ? What does this part of the brain control? What is the effect of its being injured?* Illustrate. Describe the spinal cord. What is the medulla oblongata? Describe the nerves.

165. Is each part of the body supplied with its own nerve? Prove it. What are the motory nerves? The sensory? When will motion be lost and feeling remain, and *vice versa*? What is meant by a transfer of pain? Illustrate.

166. Name the three classes of nerves. What are the spinal nerves? Describe the origin of the spinal nerve. What are the cranial nerves?

* The tamping-iron, and the skull of the man spoken of on page 163, are preserved in the Warren Anatomical Museum, Boston. It is noticeable that the man afterward became changed in disposition, fickle, impatient of restraint, and profane, which he was not before. He died epileptic, probably from progressive disease of the brain, nearly thirteen years after the injury.—PARSONS.

167-8. Name the cranial nerves.

169. Describe the sympathetic system. What is its use? How does the brain control all the vital processes? What is meant by the crossing of the cords? What is the effect? What exception in the seventh pair of cranial nerves? What is reflex action?

170. Give illustrations. Give instances of the unconscious action of the brain.* Can there be feeling or motion in the lower limb?

* Dr. Carpenter, in the course of a recent lecture at Manchester, England, upon the "Unconscious action of the Brain," gave the following among other illustrations:—1. We find that when we set off in the morning with the intention of going to our place of employment, not only do our legs move without our consciousness, if we are attending to something entirely different, but we guide ourselves in our walk through the streets; we do not run up against anybody we meet; we do not strike ourselves against the lamp-posts; and we take the appropriate turns which are habitual to us. It has often happened to myself, and I dare say it has happened to every one of you, that you have intended to go somewhere else—that when you started you intended instead of going in the direct line to which you were daily accustomed, to go a little out of your way to perform some little commission; but you have got into a train of thought and forgotten yourself, and you find that you are half-way along your accustomed track before you become aware of it. Now, there, you see, is the same automatic action of these sensory ganglia—we see, we hear—for instance, we hear the rumbling of the carriages, and we avoid them without thinking of it—our muscles act in response to these sights and sounds—and yet all this is done without our intentional direction—they do it for us. We arrive at a certain point where we are accustomed to stop, and are surprised that we have reached it. You will ask me, perhaps, "What is the exciting cause of this succession of actions in walking?" I believe it is the contact of the ground with the foot at each movement. We put down the foot, that suggests as it were to the spinal cord the next movement of the leg in advance, and that foot comes down in its turn; and so we follow with this regular rhythmical succession of movements. It is all done through the reflex action of the spinal cord.

2. The cerebellum has its unconscious action in the processes of respiration, the involuntary movements which are made in response to the senses, as in winking, starting back at a sound, etc.

3. The cerebrum acts automatically in cases familiar to all. A large part of our mental activity consists of this unconscious work of the brain. There are many cases in which the mind has obviously worked more clearly and more successfully in this automatic condition, when left entirely to itself, than when we have been cudgeling our brains, so to speak, to get the solution. An instance was put on record by a gentleman well known in London, the Rev. John De Liefde, a Dutch clergyman, who gave it on the authority of a fellow-student who had been at the college at which he studied in early life. He had been attending a class in mathematics, and the professor said to his students one day: "A question of great difficulty has been referred to me by a banker—a very complicated question of accounts, which they have not themselves been able to bring to a satisfactory issue, and they have asked my assistance. I have been trying, and I cannot resolve it. I have covered whole sheets of paper with calculations, and have not been able to make it out. Will you try?" He gave it to them as a sort of prob-

when the spinal cord is destroyed? What does the story told by Dr. John Hunter show? Give illustrations of the independent action of the spinal cord in animals.

171. What are the uses of reflex action? State its value in the formation of habits.

172. How does the brain grow? What laws govern it? What must be the effect of constant light-reading? Of over-study or mental labor? State the relation of sleep to repair and waste. How many hours does each person need? What kind of work requires most sleep?

173. What three stages are there in the effect of alcohol on the nervous systems. Describe each. Does alcohol confer any permanent strength?

174. What is the influence of sunlight on the body? Illustrate.

175. Name some of the wonders of the brain.



THE SPECIAL SENSES.

179. WHAT is a sense? Name the five senses. To what organ do all the senses minister? If the nerve leading to any organ of sense be cut, what would be the effect?* Sometimes persons lose feeling in a limb, but retain motion: why is this? What is the sense of touch sometimes called? Describe the organ of touch. What are the papillæ? Where are they most abundant?† What are the

lem, and said he should be extremely obliged to any one who would bring him the solution by a certain day. This gentleman tried it over and over again; he covered many slates with figures, but could not succeed in resolving it. He was "put on his mettle," and determined to achieve the result. But he went to bed on the night before the solution was to be given in, without having succeeded. In the morning, when he went to his desk, he found the whole problem worked out in his own hand. He was perfectly satisfied that it was his own hand; and this was a very curious part of it—that the result was correctly obtained by a process very much shorter than any he had tried. He had covered three or four sheets of paper in his attempts, and this was all worked out upon one page, and correctly worked, as the result proved.

* Each organ is adapted to receive a peculiar kind of impression. Hence we cannot smell with the eyes nor see with the nose. So that if the nerve communicating between the brain and any organ be destroyed, that means of knowledge is cut off.

† If we apply the points of a compass blunted with cork to different parts of

uses of this sense? What special knowledge do we obtain by it? Why do we always desire to handle anything curious? Can the sense of touch always be relied upon? Illustrate.

180. Show how capable this sense is of cultivation. Illustrate. What is the *tactus eruditus*? Illustrate. Tell how one sense can take the place of another. Give illustrations of the delicacy of touch possessed by the blind.

181. Describe the sense of taste. How can you see the papillæ of taste?

182. What causes the velvety look of the tongue? Why do salt and bitter flavors induce vomiting? Why does an acid "pucker" the face? What substances are tasteless? Illustrate. Has sulphur any taste? Chalk? Sand? What is the use of this sense? Does it not also add to the pleasures of life? Why are the acts of eating, drinking, etc., thus made sources of happiness? Describe the organ of smell. State the intimate relation which exists between the senses of smell and taste. Name some common mistakes which occur in consequence.

183. Must the object to be smelled touch the nose? What is the theory of smell? How do you account for the statement made in the note concerning musk and ambergris?

184. What are the uses of this sense? Are agreeable odors healthy, and disagreeable ones unhealthy? Describe the organ of hearing.

185. Describe the external ear. What is the tympanum or drum of the ear? Describe the middle ear. Name the bones of the ear. Describe their structure. Describe the internal ear. By what other name is it known? What substances float in the liquid which fills the labyrinth? What is their use? Describe the fibres of Corti.

186. What do they form? Use of this microscopic harp? Give the theory of sound. Where is the sound, in the external object or in the mind? Can there be any sound, then, where there is no mind? What advice is given concerning the care of the ear? How can insects be removed? Which sense would you rather lose, hearing or sight? Does not a blind person always excite more sympathy than a deaf one? How does the sight assist the hearing?*

the body, we can distinguish the two points at one-twenty-fourth of an inch apart on the tongue, one-sixteenth of an inch on the lips, one-twelfth of an inch on the tips of the fingers, and one-half inch on the great toe; while, if they are one inch on the cheek, and two inches on the back, they will scarcely produce a separate sensation.—HUXLEY.

* In *hearing*, the attention is more or less characteristic. If we wish to dis-

187. Describe the eye. Name the three coats of which it is composed? Is it a perfect sphere? *Ans.* The cornea projects in front, and the optic nerve at the back sticks out like a handle, while the ball itself has its longest diameter from side to side. How is the interior divided? Object of the crystalline lens?

188. How is the crystalline lens kept in place? Describe the liquids which fill the two chambers. What is the pupil? Describe the eyelids. Why is the inner side of the eyelid so sensitive? What is the cause of a black eye? Use of the eyelashes? Where are the oil-glands located? What is their use? Describe the lachrymal gland.

190. The lachrymal lake. What causes the overflow in old age? Explain the structure of the retina.

191. Use of the rods and cones. What is the blind spot? Illustrate. What is the theory of sight? Illustrate.

192. State the action of the crystalline lens. Its power of adaptation.

193. Cause of near-sightedness? How remedied? Cause of far-sightedness? How remedied? Do children ever need spectacles?

194. What is the cataract? How cured? What care should be taken of the eyes? Should one constantly lean forward over his book or work? What special care should near-sighted children take? By what carelessness may we impair our sight? Should we ever read or write at twilight? Danger of reading upon the cars? What course should we take when objects get into the eye? How may they be removed?

195. Are "eye-stones" useful? Why we should never use eye-washes except upon the advice of a competent physician? What care should be taken with regard to the direction of the light when we are at work?

tinguish a distant noise, or perceive a sound, the head inclines and turns in such a manner as to present the external ear in the direction of the sound, at the same time the eyes are fixed and partially closed. The movement of the lips of his interlocutor is the usual means by which the deaf man supplies the want of hearing; the eyes and the entire head, from its position, having a peculiar and painful expression of attention. In looking at the portrait of La Condamine, it was easily recognized as that of a deaf person. Even when hearing is perfect, the eyes act sometimes as auxiliaries to it. In order to understand an orator perfectly, it seems necessary to see him—the gestures and the expression of the face seeming to add to the clearness of the words. The lesson of a teacher cannot be well understood if any obstacle is interposed between him and the eyes of the listening pupil. So that if a pupil's eyes wander, we know that he is not attentive.—*Wonders of the Human Body.*

197. State some of the benefits of health. Contrast it with sickness. How were diseases formerly supposed to be caused? What remedies were used? What does modern science teach us to be the nature of disease?

198. Give some illustrations showing how diseases may be prevented. Is it probable that the body was intended to give out in any one of its organs? *

199. What is the first step to be taken in the cure of a disease? What should be the object of medicine? What is now the chief dependence of the best physicians? What do you think concerning the common use of patent nostrums? Relate the story told of the remedy employed by the African medicine-man. Ought we not to use the greatest care in the selection of our physician to secure the highest medical skill and cultivation?

* "So long as the phenomena of waste and repair are in harmony—so long, in other words, as the builder follows the scavenger—so long man exists in integrity and repair—just, indeed, as houses exist. Derange nutrition, and at once degeneration, or rather let us say, alteration begins. Alas! that we are so ignorant that there are many things about our house, which, seeing them weaken, we know not how to strengthen. About the brick and the mortar, the frame and the rafters, we are not unlearned; but within are many complexities, many chinks and crannies, full in themselves of secondary chinks and crannies, and these so small, so deep, so recessed, that it happens every day that the destroyer settles himself in some place so obscure, that while he kills, he laughs at defiance. You or I meet with an accident in our watch. We consult the watchmaker, and he repairs the injury. If we were all that watchmakers, like ourselves, should be, a man could be made to keep time until he died from old age or annihilating accident. This I firmly and fully believe."—*Odd Hours of a Physician*.

ANALYSIS OF THE SKELETON.

Note.—The following Table of 206 bones is exclusive of the 8 sesamoid bones which occur in pairs at the roots of the thumb and great toe, making 214 as given by Leidy and Draper. Gray omits the bones of the ear, and names 200 as the total number.

1. THE CRANUM (8 bones)	Frontal bone (forehead). Two Parietal bones. Two Temporal (temple) bones. Sphenoid bone. Ethmoid (sieve-like bone at root of nose). Occipital bone (back and base of skull).
1. THE HEAD (28 bones.)	Two Superior Maxillary (upper jaw) bones. Inferior Maxillary (lower jaw) bone. Two Malar (cheek) bones. Two Lachrymal bones. Two Turbinated (scroll-like bones, each side of nose). Two Nasal bones (bridge of nose). Vomer (the bone between the nostrils). Two Palate bones.
2. THE FACE (14 bones.)	Hammer. Anvil. Stirrup.
3. THE EARS (6 bones.)	

THE SKELETON. II. THE TRUNK. <i>(54 bones.)</i>	1. THE SPINAL COLUMN.	Cervical Vertebrae (seven vertebrae of the neck). Dorsal Vertebrae (twelve vertebrae of the back). Lumbar Vertebrae (five vertebrae of the loins).
	2. THE RIBS.....	True Ribs. False Ribs.
	3. THE STERNUM	(breast-bone).
	4. THE OS HYOMES	(bone at the root of tongue).
	5. THE PELVIS.....	Two Innominate. Sacrum. Coccyx.
	Shoulder.....	Clavicle. Scapula.
III. THE LIMBS. <i>(124 bones.)</i>	1. THE UPPER LIMBS .. <i>(64 bones.)</i>	Humerus. Ulna and Radius. Eight Wrist or Carpal bones. Five Metacarpal bones. Phalanges (14 bones).
	2. THE LOWER LIMBS .. <i>(60 bones.)</i>	Femur. Patella. Tibia and Fibula. Seven Tarsal bones. Five Metatarsal bones. Phalanges (14 bones).

I N D E X.

PAGE	PAGE		
ABDOMEN	88	Axis	86
Absorbing power of skin	73	BACK-BONE	27
Absorption of food	123, 145	Ball-and-socket joint	31
Achilles, Tendon of	48	Bathing	74
Adam's apple	83	Beef	147
Air, Composition of	92	Bicuspid teeth	68
" Need of	92	Bicuspid valve	113
" Action of	92	Bile	143
Air-cells	87	Black Hole of Calcutta	93
Albinos	63	Bleeding, Checking of	126
Albumen	135	Blood, The	105
Albuminour bodies	135	Blood-crystals	107
Alcohol	150, 172	Blushing	125
" Effect of, on nerves	172	Boils	79
Alimentary canal	139	Bones, The	19
Amæba	139	Bow-legs	37
Anatomy, Definition of	7	Brain	161
Ankle-joint	35	" Exercise	172
Antidotes for poison	209	Bread	148
Aorta	114	Breast-bone	29
Apoplexy	206	Breathing	89, 93
Aqueous humor	138	Bronchi	87
Arachnoid membrane	161	Bronchitis	97
Arëolar (connective) tissue	66	Burns	204
Arteries	113	Bursa	56
Arterial blood	111	 	
Articulation	28	CANAL, Alimentary	139
Asphyxia	98	" Semi-circular	185
Assimilation	138	" Haversian	22
Atlas	28	Canine teeth	68
Auditory nerve	168	Capillaries	116
Auricles of the heart	110		

PAGE	PAGE		
Carbonic acid.....	92	Cosmetics.....	73
" oxide.....	94	Cotton.....	76
Carbonaceous food.....	135	Coughing.....	90
Carpus.....	32	Cranial nerves.....	166
Cartilage.....	20	Croup.....	95
Casein.....	135	Crying.....	91
Cataract.....	193	Crystalline lens.....	187
Catarrh.....	128	" " Adjustment of.....	191
Cells of blood.....	105	Curvature of the spine.....	37
" " brain.....	159	Cuticle, The.....	6x
" " lungs.....	87	Cutis, The.....	6x
" " skin.....	62	 DANDRUFF.....	6x
Cement.....	70	Decay.....	70, 133, 199
Cerebellum.....	163	Dentals, The.....	87
Cerebrum.....	161	Dentine.....	70
Change of our bodies.....	121	Dermis.....	61
Cheese.....	147	Diaphragm.....	90
Chest.....	29	Diastole.....	110
Chilblain.....	78	Diffusion of gases.....	94
Chocolate.....	149	Digestion.....	138
Choking.....	206	Digits.....	31
Choroid.....	187	Diphtheria.....	98
Chyle.....	144	Diseases, etc.....	36, 54, 77, 96, 125, 154
Chyme.....	142	Disinfectants.....	204
Ciliary processes.....	188	Dress.....	76
Cilia, The.....	89	Drinking-water.....	221
Circulation.....	105, 117	Dropsy.....	67, 78
Clavicle.....	31	Drowning.....	207
Clothing.....	76	Duct, Thoracic.....	123
Coagulation.....	108	Duodenum.....	143
Coccyx.....	27	Dura mater.....	16x
Cochlea.....	185	Dyspepsia.....	154
Coffee.....	148	 EAR, The.....	184
Cold, A.....	126	" -ache.....	206
Cold bath.....	74, 75	" Things in the.....	208
Collar-bone.....	31	Eating, Regularity in.....	153
Complexion, The.....	63	" Rapid.....	151
Congestion.....	125	Eggs.....	147
Connective tissue.....	66	Elbow-joint.....	38
Consumption.....	94, 98	Enamel of teeth.....	70
Cooking of food.....	150	Epidermis.....	6x
Cords, Vocal.....	83	Eplglottis.....	83
Cornea.....	187	Epilepsy.....	206
Corn.....	148	Epithelium.....	143
Corns.....	78	Erysipelas.....	77
Corpuscles.....	106		
Cortian fibres.....	185, 190		

PAGE	PAGE		
Ether.....	190	Giands, Gastric.....	144
Kustachian tube.....	185	" Lachrymal.....	188
Exercise, Muscular.....	58	" Lymphatic.....	123
" Brain.....	172	" Oil.....	71
Expiration.....	90	" Parotid.....	139
Eye, The.....	187	" Perspiratory.....	72
" Adjustment of the.....	191-2	" Salivary.....	139
" Muscles of the.....	47	" Sebaceous.....	71
" Things in the.....	193	" Sweat.....	72
Eyebrows.....	188	Glosso-pharyngeal nerve.....	168
Eyelids.....	188	Glottis.....	83
Eye-stones.....	194	Grinders, The.....	68
Eye-wash.....	194	Gristle.....	24
FACE, Bones of.....	25	Gout, The.....	55
Face, Expression of.....	172	HABIT.....	171
Far-eight.....	191	Hair, The.....	63
Fat-cells.....	67	Hair-dyes.....	73
Fats, The.....	136	Hand, The.....	33
Felon.....	37	Haversian canals.....	23
Femur.....	34	Head.....	25
Fever.....	207	Hearing.....	184
Fibrin.....	108	Heart.....	109
Fibula.....	35	Heat, Distribution of.....	119
Fireplace.....	100	" Regulation of.....	120
Fish.....	147	" Production of.....	120
Fits.....	206	Hiccough.....	91
Flannel.....	76	Hinge-joints.....	33
Fluids, Digestive.....	139	Hip, The.....	34
Fontanelles, The.....	21	" -bones.....	30
Food, Absorption of.....	145	Hot bath.....	75
" Cooking of.....	150	Humerus.....	31
" Digestion of.....	138	Hydra, The.....	139
" Kinds of.....	135	Hygiene, Definition of.....	9
" Need of.....	133	Hypoglossal nerve.....	167
" Quantity of.....	151	ILEUM.....	139
Foot, The.....	35	Incisor teeth.....	68
Frost-bite.....	207	Indian corn.....	148
Fruits.....	148	Inferior vena cava.....	111
Furs.....	77	Inflammation.....	126
GALL-BLADDER (cyst).....	143	In-growing nails.....	78
Ganglion, A.....	56	Innominate.....	30
" A nerve.....	159	Inspiration.....	89
Gaping.....	91	Internal ear, The.....	185
Gastric-juice.....	141	Intestinal glands.....	144
Gelatin.....	20, 67	Intestines, The.....	143

PAGE	PAGE		
Involuntary muscles.....	44	Marrow.....	23
Iris, The.....	188	Mastication.....	139
Iron.....	136, 137	Meat, Cooking of.....	151
Ivory.....	70	Medicine.....	171, 199
JOINTS.....	24, 49	Medulla oblongata.....	164
Jugular vein.....	119, 123	Membrane, Mucous.....	66
Juice, Gastric.....	141	" Serous.....	120
" Intestinal.....	144	Metacarpal bones.....	33
" Pancreatic.....	143	Milk.....	147
Jumping.....	52	Milk-teeth.....	68
KNEE-CAP, The.....	35	Molars.....	68-9
" joint, The.....	35	Mucous membrane.....	66
LABIALS, The.....	87	Mucus.....	66
Labyrinth, The.....	185	Mumps, The.....	155
Lachrymal canals.....	189	Muscles of the body.....	41
" glands.....	188	" " " eye.....	47
" lake, The.....	189	" Contractility of.....	41
Lacteals.....	124, 145	" Movement of.....	41
Lacunæ.....	22, 23	" Number of.....	41
Lamb.....	147	" Tendons of.....	43
Large intestine.....	143	" Voluntary.....	44
Larynx.....	83	Muscular sense.....	51
Laughing.....	91	Mutton.....	147
Laws, Nature's.....	11		
Lens, Crystalline.....	187		
Levers.....	46		
Life and death.....	120		
Ligaments.....	24		
Light.....	174		
Linen.....	76		
Linguals.....	87		
Liquor, Spirituous.....	150, 173		
Lime.....	137		
Liver.....	143		
Locked-jaw.....	55		
Lower jaw.....	25		
Lumbago.....	56		
Lunching.....	153		
Lungs, The.....	88		
" Constriction of the.....	96		
Lymph, The.....	123		
Lymphatic system.....	123		
MARCH. Story of Dr.....	180	OCCULI motores, The.....	166
Odors.....		Odors.....	183
Œsophagus.....		Œsophagus.....	83
Oils, The.....		Oils.....	137
Old age.....		Old age.....	151
Olfactory nerve.....		Olfactory nerve.....	167
Optic nerve.....		Optic nerve.....	187

PAGE	PAGE		
Organs, Definition of.....	79	RADIUS.....	32
Organs of circulation.....	105	Rapid eating.....	151
Organs of digestion.....	138	Reaction.....	75
" " respiration.....	81	Reflex action.....	169
" " the voice.....	81	Respiration.....	87, 89
Osmose of liquids.....	145	Retina.....	187, 188
" " gases.....	145	Rheumatism.....	55
Ossification.....	21	Ribs, The.....	168
Otoliths.....	185	Rickets, The.....	36
Oxygen.....	92	Russian bath, The.....	75
		SACRUM, The.....	27, 30
PALATE, The.....	84	St. Vitus's Dance.....	54
Pancreas.....	143	Saliva, The.....	139
Pancreatic juice.....	143	Salivary glands.....	139
Pancreatin.....	144	Salt.....	137
Papillæ.....	64, 65	Scapula.....	31
Parotid gland.....	130	Sclerotic coat.....	187
Patella, The.....	35	Scrofula.....	187
Pelvis, The.....	30	Scurvy.....	198
Pepsin.....	142	Sea-bathing.....	76
Pericardium.....	110	Sebaceous glands.....	71
Periosteum.....	22	Secretion, Definition of.....	139
Peristaltic movement.....	141	Semi-lunar valves.....	113
Perspiration, The.....	72	Sensation.....	265
Perspiratory glands.....	72	Senses, The.....	181
Phalanges.....	31, 33	" of hearing.....	184
Pharynx.....	84	" sight.....	187
Phosphorus.....	137	" smell.....	183
Physiology, Definition of.....	7	" taste.....	181
Pia mater.....	161	" touch.....	179
Pigment.....	63	Serous membrane.....	110
Plasma.....	105	Serum.....	108
Pleura.....	89	Shoulder-blade.....	31
Pleurisy.....	98	" -joint.....	31
Pneumogastric nerve.....	167	Sick, Care of.....	203
Pneumonia.....	98	Sick-room.....	203
Poisons.....	209	Sighing.....	90
Pork.....	147	Sight, Sense of.....	187
Potatoes.....	148	Sinew (tendon).....	43
Processes.....	27	Skeleton, The.....	19
Ptyalin.....	140	Skin, The.....	61
Pulmonary arteries.....	118	Skull, The.....	83
" veins.....	119	Sleep.....	172
Pulse.....	114	" by medicine.....	172
Pupil.....	188	Sleeping-room.....	93
Pylorus.....	145	Small intestine, The.....	144

PAGE	PAGE		
Smell, Sense of.....	182	Thorax.....	89
Sneezing.....	90	Throat.....	83
Snoring.....	90	Tibia.....	35
Sound, Theory of.....	186	Tight-lacing	96
Special senses.....	179	Tissues, Definition of.....	24
Speech.....	85	Tobacco.....	149
Spectacles	192	Tongue, The.....	85, 181
Spinal column, The.....	27	Tooth-ache, The.....	206
" cord.....	164	Touch, Sense of.....	179
Spine, The.....	27	Trachea	87
Spirituos liquors.....	150, 172	Transfusion.....	108
Spleen.....	139	Tricuspid valve.....	113
Sprain.....	38	Trifacial nerve.....	167
Squinting.....	193	Trunk, The.....	27
Stammering.....	99	Tympanum	185
Starch.....	136		
Sternum	29	ULNA, The	38
Stomach.....	141	Unconscious action of the brain	170, 225
Stoves	94		
Sugars, The.....	135	VALVES of the heart.....	111
Sunlight.....	174	" " " veins	115
Sunstroke.....	207	Vapor bath.....	75
Superior vena cava.....	118	Varicose veins	116
Sutures.....	26	Veins, The.....	115
Swallowing, Act of.....	140	Velocity of the blood.....	119
Sweat.....	72	Vena cava.....	109
" -glands	72	Venous blood.....	111
Swimming.....	76	" system.....	115
Sympathetic system.....	169	Ventilation	94
Synovial membrane.....	24	Ventricles	110
Synovia.....	24	Vertebrae	27
Systole.....	110	Vertebral column	27, 28
		Villi of intestines	145
TACTUS ERUDITUS.....	180	Vitreous humor	188
Tartar.....	71	Vocal cords	83
Taste, Sense of.....	181	Vocalization	85
Tea.....	149	Voice, The.....	84, 85
Tears, The.....	188	Voluntary muscles	44
Teeth, The.....	68		
" Decay of	70	WALKING	50
" Indestructibility of	70	Warts	78
" Preservation of	71	Washing	74
Temperature of the body.....	120, 219	Water	221
Tendons.....	45	" in food	136
Theobromine	149	Wens	79
Thigh.....	34	Windpipe	87
Thoracic duct.....	193	Wisdom teeth	69

	PAGE		PAGE
Wonders of the brain.....	175	Woolen clothing.....	77
" " digestion.....	145, 153	Worms.....	78
" " heart.....	181	Wounds.....	125, 205
" " muscles.....	54	Wrist-joint	38
" " respiration.....	96	YAWNING	91
Woolen.....	76		







To avoid fine, this book should be returned on
or before the date last stamped below

100-3-40

01/6 17 62

TX
612.2
5814

592575

Steele, I.D.,
Fourteen weeks in physiology.

DATE

NAME

DATE

LIBRARY, SCHOOL OF EDUCATION, STANFORD
592575

